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EMPLOYMENT

MICROSCOPE

BY TWO PARTS

Part I. containing the Principles of Optics, and the Construction of the Microscope, with the History of the Art, and the Description of the Instruments used in it.

Part II. containing the Description of the Microscopic Objects, and the Methods of preparing them for Observation.

By JOHN WALL, Esq. F.R.S. &c.

London, Printed by J. Sturges, in Pall-mal, 1784.

Price 10s. 6d.

For Sale by J. Sturges, in Pall-mal, and by all the Booksellers in Great-Britain.

Printed and Sold by J. Sturges, in Pall-mal, 1784.

EMPLOYMENT FOR THE MICROSCOPE.

In TWO PARTS.

I. An Examination of *Salts* and *Saline Substances*, their amazing *Configurations* and *Crystals*, as formed under the Eye of the *Observer* :

WITH

Plain Directions how to prepare such Substances, and preserve them in constant Readiness for Inspection; whereby the *Curious* may always be furnished with numberless Objects hitherto little known.

ALSO

Occasional Considerations on *Gems*, *Poisons*, the *Vegetation of Metals*, the *Resuscitation of Plants*, the *Formation of Amber*, *Corals*, and many other Subjects.

II. An Account of various ANIMALCULES never before described, and of many other *Microscopical* DISCOVERIES :
With OBSERVATIONS and REMARKS.

LIKEWISE

A Description of the MICROSCOPE used in these Experiments, and of a new *Micrometer* serving to shew the Size of magnified Objects.

Together with

Instructions for printing off any *Medal* or *Coin*.

Illustrated with Seventeen COPPER PLATES.

By HENRY BAKER, Fellow of the *Royal Society*, and Member of the Society of *Antiquaries* of *London*.

Reerum Natura nusquam magis quàm in Minimis tota est.
PLIN. Hist. Nat. Lib. XI. cap. 2.

L O N D O N :

Printed for R. DODSLEY, at *Tully's-Head* in *Pall-mall*; and sold by M. COOPER in *Pater-noster-Row*; and J. CUFF, Optician in *Fleet-street*. 1753.

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TO THE
RIGHT HONOURABLE
The Earl of Cardigan.

My LORD,



IS Grace the late Duke of MONTAGU, (whose Name must be ever dear to all that knew him) was pleased to honour, with his particular Notice, the Experiments and Observations described in the following Sheets, and frequently expressed his Desire of having them made public: and as your Lordship seemed no less to admire these wonderful Operations of Nature, I take the Liberty to request

iv DEDICATION.

your Acceptance of a Work, whose Novelty and Variety will I hope yield you some Entertainment, at the same time it affords me the desirable Opportunity of professing my most humble Respect.

The first Part of this Treatise discovers in the Particles of Matter composing Salts and saline Substances, Properties whose amazing Effects would surpass all human Belief or Conception, were we not convinced of their Truth by the strongest ocular Demonstration. That beautiful Order in which they arrange themselves and come together under the Eye, after being separated and set at Liberty by Diffolution, is here described and shewn.— Did they amongst them all compose but one kind of figure, however simple, with Constancy and Regularity, we should declare it wonderful : What must we then

DEDICATION. v

then say, when we behold every Species working as it were on a different Plan, producing Cubes, Rhombs, Pyramids, Pentagons, Hexagons, Octagons, or some other curious Figures peculiar to itself; or composing a Variety of Ramifications, Lines, and Angles, with a greater Mathematical Exactness than the most skilful Hand could draw them ?

Sensible of my own Ignorance, I pretend not to account how this is done : all I know is, that Chance or Accident cannot possibly produce Constancy and Order, nor inert Matter give Activity and Direction to itself. When therefore these Particles of Salts are seen to move in Rank and File, obedient to unalterable Laws, and compose regular and determined Figures, we must recur to that Almighty Wisdom and Power which planned out the System of Nature,

vi DEDICATION.

ture, directs the Courses of the Heavens, and governs the whole Universe.

The Experiments here described, and which the Reader is instructed to make, must I think generally entertain; but merely to entertain, is, I hope, the least of their Worth. They may possibly lead to the Knowledge of what passes in the Formation of Gems, and the most beautiful mineral Productions: And as every new Discovery is an Encouragement to farther Disquisition, the Hints here given may perhaps set abler Heads at Work to improve Art on the Principles of Nature. Examinations by the Microscope, in the Manner here directed, may likewise be employed to ascertain the Truth and Purity of many simple Substances and Compositions made use of in Medicine, and detect Fraud and Imposition.

The

DEDICATION. vij

The minute living Animals exhibited in the second Part of this Work, will excite a considerate Mind to admire in how small a Compass Life can be contained, what various Organs it can actuate, and by what different Means it can subsist. They will also shew that the Hand which made them is not confined to Size or Form; and that it has not been wanting to bestow on Creatures almost invisible, and seemingly inconsiderable, every Member and Faculty convenient to their Happiness.—But this is an endless Subject, with which I shall detain you no longer than to observe, that were there wanting Proofs of a DEITY, they might here I think be found in great Abundance.

Your Lordship's great Condescension and Goodness, in honouring this Work and its Author with your Pa-

viii DEDICATION.

tronage, must always be remembered
and acknowledged with the utmost
Gratitude, by,

My LORD,

Your Lordship's much Obliged

and most Obedient

Humble Servant,

HENRY BAKER.

P R E F A C E.

*'T*IS hoped the Book now published will be accepted favourably by the Curious, and particularly by those acquainted with the uses of the Microscope, as it opens to their View an almost inexhaustible Store of Objects for that Instrument; and many who are Strangers to it, may, 'tis likewise hoped, be excited by what they read here, to lend some Attention to such of Nature's wonderful Productions as cannot be known without it. The earnest Wish and Desire of the Author is, that all People would see with their own Eyes, and determine by their own Judgment; neither rashly disbelieving what is here related because it may seem surprizing, nor lazily giving it Credit on his bare Word without making Experiments themselves.

As many of both Sexes who have not had the Advantage of a learned Education, are notwithstanding greatly desirous of Knowledge; for the Sake of such, this Treatise is written in Terms most easy to be understood; and a short Account of the several Substances here examined is given for their Information.

He

He begs Pardon of the Physicians and Chemists, for encroaching now and then on their Province, in the Course of the following Observations and Remarks; and hopes they will generously excuse any Mistakes he may have fallen into, as he is neither Physician nor Chemist. Those too who are themselves well acquainted with the Subjects here described, will not, he hopes, be displeas'd at his endeavouring to instruct such as know them not.

He acknowledges his Obligations to many ingenious Friends, who have favoured him with their Observations from Time to Time, several of which are inserted in this Work; and shall always be thankful to any Gentleman who will send him an Account of whatever he thinks remarkable.



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MISTAKES.

P. 233. Before the last Line but one insert *was*.

P. 374. In the last Line of the Chapter, for $\frac{5}{3000}$ read $\frac{1}{1000}$.

In the *Second Part* CHAP. XXIV. ought to have been XXIII, and so on to the End.



EMPLOYMENT

FOR THE

Microscope, &c.

CHAP. I.

Concerning the CONFIGURATIONS and CRYSTALS of SALTS and SALINE SUBSTANCES.



AS I wish nothing more heartily than the real Advancement of useful Knowledge, by discovering, as far as possible, the Operations of Nature in the Formation of Bodies, and their Effects on one another: and as the most reasonable Way of accounting for their Effects must arise from a Discovery and Consideration of the Figure, Size, Solidity, Weight and Motion, of their

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constituent Parts ; since we do not, I think, suppose Body to act on Body by any other Principles * : I have long imagined, that if by an easy and natural Separation of such their constituent Parts, it were possible to know the comparative Size and Figure, Solidity and Motion of the Particles compounding Bodies, when so separated from one another ; and if we could also learn in what Order and Figure they naturally come together, and re-unite after such a Separation, it might lay a Foundation whereon some able Builder may erect a valuable Superstructure.

With this View I have been making Experiments, almost continually, for above ten Years past, on a great Variety of Saline Bodies, Mineral, Vegetable and Animal, as well as many other Substances, both simple and compound, whose Parts can be dissolved in Fluids, after a Method which has never hitherto been described by any Author, or practised before myself by any body that I have heard of. And tho' I have found their original Particles undiscoverable by any Microscope, the Time I hope has not been wholly misemployed ; since I have been enabled, by the help of that Instrument, to behold the amazing Order
and

* Unless the new discovered Properties of *Electricity* be imagined owing to some Causes we are not yet acquainted with.

and Regularity, wherewith, after being separated by Diffolution, they come together and re-unite under the Eye, when put in Action by certain Degrees of Heat, in Configurations appropriated to each of them respectively, and with a Constancy that is surprizing.

That particular Notice, wherewith the ROYAL SOCIETY was pleased to honour these Experiments, † encouraged me to prosecute them with all the Care in my Power, to minute down every remarkable Circumstance in the Process, and to make faithful Drawings of each Configuration.

Much has been already published by several curious Observers concerning the Crystalizations and regular Figures of Salts, and none I hope will imagine I am hereby endeavouring to deprive them either of their Discoveries or their due Praise. But I pre-

B 2 sume

† After many repeated Examinations of Salts and Saline Substances by the Help of Glasses, in the Winter of the Year 1743, I had the Honour twice of entertaining the ROYAL SOCIETY with a View of their Configurations, which were then thought so extraordinary, that very many of that illustrious Body came often afterwards to see them more at Leisure at my Lodgings, and in the Year 1744, Sir HANS SLOANE, Bart. late President of that Society, was pleased, at the Recommendation of his worthy Successor MARTIN FOLKES, Esq; and of the Council of the said Society, to bestow on me the Medal of Gold, annually presented (as the Donation of Sir GODFREY COPLEY, Bart. of which Sir HANS is the only surviving Trustee) to whomsoever of their Members shall be deemed to have produced the most extraordinary Discovery during the whole Year.

4 *Configurations and Crystals*

sume my Experiments go a great deal farther, both as to the Manner of Examination, and the Variety of Subjects examined: for by the Assistance of Heat, which in a greater or less Degree is perhaps a constant Agent in all the Operations of Nature, very different Configurations and Effects are produced than what can be caus'd without it, and our Information is thereby render'd much more compleat and perfect.

To give one single Instance of this, which takes place equally in most other Subjects: The Crystals of Alum are well known, and their Figures (when a Solution of it is permitted to crystalize quietly and of itself) have been truly described and pictured by others to be octaëdra, consisting of hexangular, triangular and quadrangular Planes: but nobody I believe has before discover'd, at least nobody hitherto has informed the World, that the Particles of Alum, when separated by Dissolution, and excited to Action by a certain Degree of Heat, so arrange themselves as to compose regular and delightful Star-like Figures of different Sizes, many whereof have long streaming Tails and resemble Comets: that it shoots forth in some Places Figures like Palisadoes, and in others an almost infinite number of parallel Lines, most exquisitely strait, exact and fine; some crossing others at right Angles, and composing an Appearance
beyond

beyond Description beautiful. *Vide Plate III.* No. I. Indeed the Production of the Star-like Figures depends on a certain Nicety in the Heat continued for a certain Time, which one is not always sure to hit precisely; and therefore, though they appear very frequently, they are not quite so constant in every Trial as its other Configurations; but I doubt not Practice and Observation will render them so in Time.

I must beg leave to call these Arrangements of the Particles by the Name of Configurations, thereby to distinguish them from the Crystalizations mentioned by others, whereto they bear little or no Resemblance. Crystalizations seem produced by a Tendency or Attraction of the Saline Particles towards certain Points, about which they combine in regular and determin'd Forms, according to their respective Kinds. Configurations owe their Shapes most probably to different Fits of Repulsion and Attraction, (those two wonderful Principles which occasion most of the Changes in Nature) taking place at certain Intervals and in certain Proportions, and operating according to Rules that are constant and uniform, though little known to us at present. Or if, to make the Subject understood the better, I may be permitted to fetch a Comparison from a common Supposition, without examining whether it

6 *Configurations and Crystals*

be true or false, Crystallization is like the retiring of the Sap into the Roots of Trees at the Approach of Winter, where during the cold Season it remains dormant and unactive : Configuration resembles what results from the Expansion of the same Sap at the Return of Spring, when excited to Action by the Sun's genial Warmth, it pushes every Way, exerts its vegetative Force, and becomes productive of Buds, Leaves, Branches, Blossoms and Fruits. But the Drawings of one and the other compared together and consider'd, will render this Difference more intelligible than all the Words in Language.

The beautiful Regularity and Order always observable in the Works of Nature, are no where more evident than in the Experiments I am mentioning ; where the invisible Particles of Matter, though disunited by a Menstruum, and removed to Distances from each other, are no sooner excited to Action than they mutually assist one another to compose Figures peculiar to their several Kinds, with as much Certainty and Uniformity as Seeds of the same Plant produce Plants like one another, not indeed precisely as to the Number or Position of their Branches, Leaves or Flowers, but in the general Growth and Fashion, and those other Particularities whereby each Species is distinguished.

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Our Eyes are continually accustomed to see the Productions of Nature when finished, or brought a considerable Way towards it ; and what contemplative Man can behold them without Admiration and Delight ! but in these Experiments we are enabled, by the Assistance of Glasses, to view her actually at Work, forming under our Eyes, and in a few Minutes, Bodies so exquisitely beautiful that nothing but Seeing can give any just Idea of them ; and that too with such a Variety, as to the Plan and Fashion of each Kind, as is absolutely unconceivable.

Descriptions of the Subjects here treated of would be unintelligible without the Assistance of Drawings. Drawings therefore have been made, and Copper Plates engraved, at no small Expence, of the different Configurations hereafter mentioned : which, though greatly deficient in Beauty and Regularity, if compared with the Originals, and only pretending to give such a general Resemblance as may distinguish each Kind from other, will 'tis hoped prove satisfactory to those who shall please to repeat the Experiments after me : for however strange they may appear, they are no fanciful Representations produced by the Strength of Imagination, nor are they taken hastily from one or two Trials, but truly shew what generally presented in

great Numbers of repeated Observations. Their Figures are indeed so extraordinary, that I should not dare to have laid them before any body, much less to have published them, were there not many Gentlemen of unexceptionable Credit who are living Witnesses of their Truth, and was I not also able, almost at any Time, to produce Configurations like those they were taken from.

These constant and regular Workings of Nature, which the Microscope discovers, may possibly conduct us a Step farther into her Recesses, and assist us to judge of Causes and Effects in many Cases where at present we are greatly at a Loss, since according to Dr. *Woodward* †, “ the Steadiness and Constancy of Nature in all its Productions, and in the Formation of all Bodies, happens from the Constancy of the Procedure of the Agents that are instrumental to the Formation of those Bodies, and from the Unalterableness of the Corpuscles which serve for constituting and composing of those Bodies ” And we are told by the Rt. Rev. Author of *Syris* ‡, that the “ Analogy, Constancy and Uniformity in the Phænomena or Appearances of Nature are a Foundation for general Rules : and these are a Grammar for the Understanding of Nature, or the Series of

† Vid *Woodward's* Nat. Hist. of Fossils, *Eng. Edit.* Vol. I. p. 186.

‡ Sect. 122.

“ of Effects in the visible World, whereby
“ we are inabled to foresee what will come
“ to pass in the natural Course of Things.”

As there is good Reason therefore to expect, that the following Experiments may conduce something towards accounting for many Causes and Effects in Nature, when duely considered by People of true Judgment, to such I freely submit them; without pretending any thing more myself than barely to relate Facts: but should they serve no other Purpose than to present a new Set of Objects for the Microscope, full as wonderful and entertaining as any that have ever been yet examined, affording by Mixture a Variety almost infinite, easily procured, and always ready for Observation, there are many I flatter myself to whom they will prove acceptable. And I shall endeavour to assist as much as possible the Curiosity of those who may be inclined to repeat these Experiments after me, by describing in the plainest Terms each Circumstance necessary to be known, either previous to, or during the Time of Observation by the Microscope, and dare assure them for their Encouragement, that the Trouble is very little, though the Pleasure and Information resulting therefrom is great.

To begin then with the Manner of preparing these Subjects for Observation.

C H A P. II.

The Method of preparing SALTS and SALINE SUBSTANCES, for the viewing their CONFIGURATIONS.

I Dissolve the Subject to be examined in no larger a Quantity of River or Rain Water than I am certain it is sufficient to saturate. If it is a Body easily dissolvable I make use of cold Water, otherwise I make the Water warm, or hot, or even boiling, according as I find it necessary. After it is perfectly dissolved I let it rest for some Hours, till, if overcharged, the redundant Saline Particles may be precipitated, and settle at the Bottom, or shoot into Crystals; by which means I am most likely to have a Solution of the same Strength at one Time as at another; that is, a Solution fully charged with as much as it can hold up, and no more; and by these Precautions the Configurations appear alike, how often so ever tryed: whereas if the Water be less saturated, the Proportions at different Times will be subject to more Uncertainty; and if it be examined before such Separation and Precipitation of the redundant Salts, little more will be seen than a confused Mass of Crystals.

The Solution being thus prepared, I take up a Drop of it with a Goose Quill, cut in Fashion

Fashion of a Scoop, and place it on a flat Slip of Glass of about three Quarters of an Inch in Width, and between three and four Inches long, spreading it on the Glass with the Quill, in either a round or oval Figure, till it appears a Quarter of an Inch or more in Diameter, and so shallow as to rise very little above the surface of the Glass. When it is so disposed, I hold it as level as I can over the clear Part of a Fire that is not too fierce, or over the Flame of a Candle at a Distance proportionable to the Degree of Heat it requires, (which Experience only can direct,) and watch it very carefully, till I discover the Saline Particles beginning to gather and look white, or of some other Colour, at the Extremities of the Edges. Then (having adjusted the Microscope beforehand for its Reception, armed with the fourth Glass, which is the fittest for most of these Experiments,) I place it under my Eye, and bring it exactly to the Focus of the Magnifier, and after running over the whole Drop, I fix my Attention on that Side where I observe any Increase or pushing forwards of crystalline Matter from the Circumference towards the Center.

This Motion is extremely slow at the Beginning, unless the Drop has been overheated, but quickens as the Water evaporates, and in many Kinds towards the Conclusion produces Configurations with a Swiftnes

unconceiveable, composed of an Infinity of Parts, which are adjusted to each other with an Elegance, Regularity and Order, beyond what the exactest Pencil in the World guided by the Ruler and Compasses can ever equal, or the most luxuriant Imagination fancy.

When Action once begins, the Eye cannot be taken off, even for a Moment, without losing something worth Observation: for the Figures alter every Instant till the whole Process is over; and in many Sorts, after all seems at an End, new Forms arise, different intirely from any that appeared before, and which probably are owing to some small Quantity of Salt of another Kind, which the other separates from and leaves to act after itself has done: and in some Subjects three or four different Sorts are observable, few or none being simple and homogeneous.

When the Configurations are fully formed, and all the Water evaporated, most Kinds of them are soon destroyed again by the Moisture or Action of the Air upon them; their Points and Angles lose their Sharpness, become uneven and defaced, and moulder as it were away. But some few are permanent, and by being inclosed between Glasses, as I shall direct hereafter, may be preserved Months, or even Years, entertaining Objects for the Microscope,

N. B. It happens oftentimes that a Drop of a Saline Solution can hardly be spread on the Slip of Glafs, by reason of the Glafs's Smoothness, but breaks into little Globules, as it would do were the Surface greasy ; this was very troublesome, till I found a way of preventing it, by rubbing the broken Drop with my Finger over the Glafs, so as to leave the Glafs smear'd with it ; on which smear'd Place when dry, another Drop of the Solution may be spread very easily in what Form one pleases.

It likewise sometimes happens, that when a heated Drop is placed properly enough for Examination, the Observer finds he can distinguish nothing : which is owing to Saline Steams that rise from the Drop, cover and obscure the Object Glafs, and therefore must immediately be wiped away with a soft Cloth or Leather.

'Tis I think an allowed Maxim, that Salts act not unless in a State of Dissolution, for which Reason I dissolved them in order to observe their Manner of acting. A certain Degree of Heat is likewise most commonly employ'd by Nature in all her various Productions : wherefore I imagined that by the Assistance of Heat, applied in different Degrees, I might in some sort imitate Nature, and produce such Figures as Salts are thrown into, not when they cease to act, which I apprehend is the Case when they
are

are formed into Crystals, but even whilst they are acting : and this what I call their Configuration does most wonderfully shew.

My Intention was to discover as far as might be, the natural Inclination, Progression and Figure of each respective Salt under Examination ; it was consequently necessary to avoid making use of any Dissolvent, which by containing other Salts might create Confusion, and produce Forms not constant or essential to the Subject of Inquiry. River or Rain Water has therefore most commonly been my Dissolvent, being what I judged least likely to prejudice my Experiments. I am very sensible neither Salts or other Bodies are to be obtained unmixed and perfectly homogeneous : but I have taken pains to procure such of each Kind as appeared most pure and perfect, I mean of the simple Salts ; as for the Compounds I was obliged to rely on the Chemist.

In all Examinations by the Microscope of Saline Solutions, even though made in the Day-time, I always employ the Light of a Candle, and advise every Observer to do so likewise : for the Configurations being exceedingly transparent, are rendered much more distinguishable by the brown Light a Candle affords, than by the more white and transparent Day-light ; and besides, either by moving the Candle or turning

ing the Microscope, such Light may be varied or directed just as the Subject requires.

It may be also proper to take notice, that no Kinds of Microscope are fit for these Observations, but such as have an open Stage, whereon the Slips of Glass with the Liquor upon them may be placed readily, and in a perfect horizontal Position; and moreover where they can be turned about freely, and without disordering the Fluid. Those Microscopes where Sliders or Slips of Glass are thrust in between two Plates, as in *Wilson's*, &c. be they in whatever Direction, cannot therefore properly be employed here.---The following Observations were all made by a double Microscope, constructed by Mr. *Cuff*, in *Fleet-street*, with some Regard to these Experiments. Its Figure resembles what is called commonly the *Double Reflecting Microscope*, and like that it receives Light from a Speculum underneath: but besides an Improvement in the Position of the Glasses, its Stage is disencumbered with Legs, and quite open for the Reception of Objects without Trouble; its Motion is not by Jerks, as in the Microscope just now mentioned, but regulated by a fine-threaded Skrew, whereby it is adjusted to the Eye with great Ease and Exactness: and all that try it will I believe judge it not only the most convenient Microscope

scope for this Purpose, but likewise for general Use. Wherefore as this Instrument, which has been constructed since the Publication of the *Microscope made easy*, could not be given there amongst the other Microscopes then in use, I intend at the End of this Treatise to insert a Drawing and short Description of it.

C H A P. III.

Of SALTS in general.

IT seems necessary, in order to make the Matter in Hand understood the better, that some Account be given of what is meant by *Salts* and *Saline Substances*, together with some short Explanation of the Dissolution of such Substances, and their Crystallization afterwards; whereby the Difference between my Experiments and those of others may become more evident.

Few will I presume imagine, that I mean by Salts such Substances only as afford what is called a Salt Taste; for Salts are of all Tastes, and Sugar itself is no other than a Salt extracted from the Sugar Cane. But we understand by Salts, all Substances whatsoever that are dissolvable in Water, or whose Parts become so separated thereby as to disappear therein; which, notwithstanding

ing the Water being evaporated, shew themselves again combined in some sort of angular Forms, with a Degree of Transparency, and to the Taste are more or less pungent. To this may be added, that they are fusible by Fire.

Salt, thus understood, is one of the first Principles of the Chemists ; and indeed has good Reason to be esteemed so, as it enters into the Composition of all Bodies. It is every where, and in every thing : for if any Stone, Plant, or Animal be burnt, a Salt remains in the Ashes, which may be extracted by Water, and separated from the *Caput Mortuum*.

It is the Nutriment of Animals, Vegetables and Minerals, infomuch that Herbs, Roots, Bread, &c. deprived of their Salts, can neither sustain, nourish, or increase the Bodies of Animals ; and the Earth when divested of it becomes absolutely barren.

Vegetables and Animals, whilst flourishing and alive, discharge by Perspiration and other more sensible Evacuations the Excess and Recrements only of the Salts whereby they are preserved : but when they perish, the Chain whereby the Parts were kept together becomes broken, the Salts regain their Liberty by Putrefaction, some fly away into the Air, and the rest remain in a Condition to enrich and render fertile.

that lean and hungry Earth which is destitute of such Salt.

Tastes, Smells, and most other Effects of Bodies on one another, seem occasioned by the Action of Salts, which by striking on our Organs produce Sensations correspondent to their Figures, and by the same means affect all other Bodies.

Being transparent, and having a strong attractive Power, they probably supply both Matter, Consistence and Form to Spars, Crystals, Diamonds, and all other Gems and pellucid angularly figured Fossils. When combined and at Rest they are perhaps the Basis of Cohesion and Solidity in most Bodies, the Pegs or Nails that hold the Parts of other Matter together ; but when put into Motion by the Separation of their component Particles, and their repulsive Force (which is no less vigorous than their attractive Power) becomes exerted, they are the most active Principles in Nature, like Knives or Launcets cut their Way through every thing, and produce the most surprizing Changes. Whence the Chemists say, that in the Sun and in Salt are all Nature's Productions ; and, that he who knows not Salts, will never perform any thing in Art.

The Distinction of Salts into acid and alkaline, into volatile, fixt, and essential, I shall leave the Reader to consult chemical Writers about.

CHAP. IV.
Of DISSOLUTION.

THE Dissolution of Salts or saline Bodies is effected by an Intrusion or Interposition of the Particles of Water, or some other Dissolvent, between the Particles that compound such Bodies; whereby their Combination is destroyed, and they become separated from each other.

Sir *Isaac Newton* accounts for the Dissolution of such Substances from the great Principle of Attraction, and the Manner thereof is explained by Dr. *Friend* in his *Prælectiones Chemicæ*, pag. 61, where he gives a mechanical Description of the dissolving of common Salt in Water; the meaning of which in few Words is, “ that the
 “ Corpuscles of Salt being extremely simple,
 “ minute, and solid for their Bulk, are con-
 “ sequently indued with a strong attractive
 “ Power: (Attraction being, *cæteris paribus*,
 “ always in proportion to the Quantity of
 “ Matter :) the Particles of Water are there-
 “ fore attracted more vigorously by the sa-
 “ line Particles than by one another: for the
 “ watery Particles cohering but slightly, and
 “ moving readily, when they approach the
 “ Particles of Salt, rush as it were into their
 “ Embraces; and opening a Passage into their

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“ Pores,

“ Pores, which are very numerous, the Texture and Cohesion of their Parts become intirely broken and destroyed, the Corpuscles are separated, and float here and there in the Water.”

Water (or some other Liquor) having thus inſinuated between the component Particles of ſaline Bodies, deſtroyed their Cohesion, and removed them from each other; if the minute diſunitied Particles are fewer than what the Interſtices of the Water can contain, they remain ſuſpended in the Fluid, though being extremely ſmall and tranſparent the Eye cannot diſcern them: for notwithstanding Salts are ſpecifically heavier than Water, their minute Particles, when ſeparated, having their Surfaces increaſed in proportion as their Bulk is diminiſhed, are unable to overcome the Reſiſtance of the Fluid, and conſequently cannot ſink therein. But if the ſaline Particles are more in Quantity than the Interſtices of the Water can eaſily contain, the Reſidue attract each other, form little Maſſes heavier than the Fluid, and either fall to the Bottom, or adhere to the Sides of the Veſſel, and that moſt commonly in the Form of regular Crystals.

C H A P. V.

Of CRYSTALIZATION.

THE usual Way of procuring Crystals from any Salt or saline Substance is, to dissolve the same in warm Water; to filter the Mixture if there be any Foulness; to evaporate till a Film is seen at Top; and then to set it in a cool Place to shoot. Heat enables the Water to dissolve and hold up a greater Quantity of the Salt than it would do without it, and Cold afterwards greatly assists its forming into Crystals.

The Crystals thus formed, whether more or less in Quantity, will always have such Figure as is peculiar and constant to the Kind of Salt they are procured from; and how often soever their Particles be separated by Solution, they will come together again, and reunite in such a Manner as to produce Bodies exactly of the same regular Forms; which must imply, that such component Particles, whatever their Shape or Texture be, are themselves unalterable, and that the Principle or Law whereby they are brought together is uniform and perpetual. Their Concretion may be accounted for on Sir *Isaac Newton's* Principles, by the attractive Force with which all Bodies, and Salts more especially, by reason of their Solidity, are indued; whereby, when the Water wherein they float

is evaporated, to such a Degree that the saline Particles come within the Reach of each other's attractive Power, and do actually attract one another more vigorously than the Fluid attracts them, they form themselves into Crystals. And as to the Regularity of their Figures, "that argues (according to the same great Man) that "the Particles of the Salt before they con- "creted, floated in the Liquor at equal "Distances in Rank and File; and by con- "sequence that they acted upon one "another by some Power which at equal "Distances is equal, at unequal Distances unequal. For by such a Power they "will range themselves uniformly, and "without it they will float irregularly, and "come together as irregularly." He also supposes, "that the Particles not only range "themselves in Rank and File for con- "creting in regular Figures, but also by some "kind of polar Virtue turn their homo- "geneal Sides the same Way †.

As that Constancy of Figure, observable in the Production of Crystals from the same Salt, proves their component Particles to have some determined and unalterable Shape, so the Difference of Figure peculiar to the Crystals of different Salts, induces one to believe, that the component Particles of each Kind differ no less in Shape

† *Newton's Opticks*, 2d Edit. Page 363.

Shape from the Particles of every other Kind than the Crystals they compose do.

The Particles of them all are indeed so exquisitely minute, that no human Eye or Instrument can possibly discern them, being finer, in several Kinds, even than the Particles of Air, forcing their Way through Metals, Glass, and other Bodies, where the Air can find no Entrance. Conjectures have notwithstanding been made concerning their Figures; some supposing them exactly of the same Shape in little, as the Crystals they constitute by their Combination are in a larger Size; whilst others insist, that their Shape is intirely different from what appears in the Crystals; the Figures whereof arise, as they imagine, from a stronger Attraction on some Sides of the same Particles than on others, whereby the Concretions on those more attractive Sides are greater: for, say they, if the Particles of Salt that swim in a Fluid attract each other mutually, and by their Figure have a greater attractive Power in some Parts than in others, and if their Contact be greatest in those Parts, such Particles will form themselves into Bodies with given Figures, or, in other Words, will constitute regular Crystals.

That ingenious mathematical Professor and Physician of *Bononia* *, *Dominicus*

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Guliel-

* Vid. *Discorso sopra le Figure de' Sali*. Printed at Bologna 4^{to}. 1688.

Gulielminus observes, that the sensible Crystals of any Salt, however large or minute they may be, have always the same Figures : the Co-ordination of the Parts not depending on the Quantity of the component Matter : that Nitre, for Example, in its Efflorescencies from Walls, disposes itself into very slender Bodies of the like Figure exactly as its larger Crystals ; and that not only Crystals too small for our Eyes to see, but even the minutest Particles of their Salt, that were dissolved in the Water before their Crystalization, have the same Figure as the larger Crystals have. Whence he supposes the first Principles of Matter whereof the Salt is composed, and which on Account of their Smallness no Force can possibly divide, to have such determined Figures, as they can never change, imposed on them at their Creation. And for this he quotes Mr. *Leeuwenhoek*, who asserts, that in Solutions of *Cyprian* Vitriol, and of Tartar, he has seen Particles, which though not larger than the twenty thousandth Part of the Thickness of a Hair, were exactly figured like their larger Crystals ; and those Figures in two or three Minutes increased to an hundred times their former Bulk, still retaining their Figure, however they were enlarged in Length and Breadth.

Nor does he imagine any other Cause
for

for the Separation of a Salt from the Fluid wherein it is dissolved, but an Inclination of the Planes of the smallest Particles to unite; which Inclination being alike in all, they join one after another on every Side: by which means the Size grows larger, but the Figure alters not. Those in common Salt he affirms to be minute Cubes, in Vitriol Parallelopipids, and in Nitre hexagonal Prisms.

Hence he infers, that the Figures of the Crystals prove not only the Existence and Shape of their component Particles, but withal demonstrate that the Crystals are themselves produced by an apposite Union of such-like figur'd Particles, whose Figures cannot be destroyed unless by Annihilation.

That the most minute Crystals discernable by the Microscope may be observ'd growing under the Eye, and enlarging their Dimensions many thousands of times without an Alteration in Figure, I dare affirm from my own Experience: but I pretend not thereby to determine the real Shape of the original Particles of any Salt, or to understand the other Properties concerned in their Combination. After all my Experiments, I am too sensible of my own Ignorance to set up any Hypothesis: that I leave to abler Judges on future Tryals; begging Leave instead thereof to submit the following Queries to be considered at Leisure.

Q U E R I E S.

Q U E R I E S.

DO not Attraction and Repulsion seem to be the principal active Powers whereby the natural Changes in Bodies are produced ?

Are not these Powers inherent, probably, in all Matter, however their Agency may be suspended, diminished, augmented, or otherwise diversified ?

May we not suppose, that by the first of these Powers the original Particles of Matter are brought together and conjoined, in the Formation of most compounded Bodies ? and does not the Destruction of such Bodies, or the Separation of their component Particles, seem probably greatly owing to the Latter ?

Is there not Reason to believe, that the Particles of Matter constituting Gold, Stone, Wood, Flesh, &c. are different from each other *ab Origine* ; and, consequently, that there are different Kinds of simple material Particles ?

Must not these Particles (however unconceivable their Minuteness be) have some determined Figures and Sizes ? May not such Figures and Sizes be different, and indued with different Degrees of the attractive or repulsive Force : and may not the Difference in Bodies as to Coherence,
Soli-

Solidity, Duration, &c. be owing to the various Intermixture and Combination of Particles either *alike*, or *unlike* in Size and Figure † ?

May there not be a Kind of *Polarity* in the original Particles ? or, may they not attract at some Points and repel at others, and that in various Proportions, according to their Inclination towards each other, their Distances, their Points of Contact, or other Circumstances ? May not such Attraction or Repulsion be excited, or suspended, by Heat, Cold, Motion, Rest, &c ? And as Light has alternate Fits of easy Reflexion and easy Transmission ‡, occasioned by the different original Properties of the different Sides of its Rays *, (as Sir *Isaac Newton* has

† “ All the Phenomena in Nature are produced by Motion. There appears an uniform working in things great and small by attracting and repelling Forces. But the particular Laws of Attraction and Repulsion are various. The minute Corpuscles are impelled and directed, that is to say, moved to and from each other, according to various Rules or Laws of Motion. Some Bodies approach together, others fly asunder, and perhaps some others do neither. When Salt of Tartar flows *per deliquium*, it is visible that the Particles of Water floating in the Air are moved towards the Particles of Salt, and joyned with them. And when we behold vulgar Salt not to flow *per deliquium*, may we not conclude that the same Law of Nature and Motion doth not obtain between its Particles and those of the floating Vapours ? A Drop of Water assumes a round Figure, because its Parts are moved towards each other : but the Particles of Oil and Vinegar have no such Disposition to Unite.” *Vide* Bishop of CLOYNE’s *Syris*, Page 110.

‡ NEWTON’S *Opticks*, Page 339. Again, 347.

* *Ibid.* *Quere* 26.

has shewn:) may there not also be alternate Fits of easy Attraction and easy Repulsion, occasioned by the Conjunction, or Opposition, of the attractive or repulsive Sides in the Particles of Matter? May not the Succession of such Fits be extremely quick, as in the Vibrations of Bodies, &c? and may they not be prevented, diminished, circumscribed, augmented, propagated, or communicated, with almost infinite Variety (as to the Modification) according to the Constitution of the Bodies wherein they are excited, and the Aptness or Unaptness of other Bodies near them?

May we suppose the Attraction and Repulsion of Magnetism, Gravity and Electricity, to be different Powers, or different Modifications only of the general attractive and repulsive Power supposed resident in all Matter?

Do not Heat and Motion seem most likely to excite Repulsion; and are not Cold and Rest most favourable to Attraction?

When the Particles of Substances evaporate, become volatile, or fly away, is not such Volatility owing to the repulsive Force of the Particles, some how or other put into Action? And is not the Explosion of Gunpowder, &c. occasioned probably by a Fit of Repulsion, excited suddenly and violently by Fire, in the component Particles of the Gunpowder?

Supposing that Salts are dissolved, or their Parts separated, (according to Sir *Isaac Newton's* Theory, and the beforementioned Explanation of Dr. *Friend*,) because the Particles of Water are more strongly attracted by the Particles of Salt than by one another, and rush between and disunite the saline Particles: may not the repulsive Power of the saline Particles, as to one another, be exerted at the same Time? or may not a Fit of Repulsion instantly succeed the former Fit of Attraction *? And, if the repulsive Power be of equal Force in each of the Particles, will they not be repelled to equal Distances from each other, and consequently be disposed in Rank and File: and when their next Fit of Attraction takes place, will they not unite according to their Arrangement and constitute regular Figures?

Without supposing such Fits of Repulsion and Attraction, will it not be very difficult to conceive, how the Particles of Salt, which, notwithstanding their mutual Attraction and Contact, became separated each from other by their stronger Attraction

* Unless by some such Means, it is not easy to imagine that the Particles of Water should be able to enter the Interstices between the constituent Particles of Salts: for the first Particles of Salts are found to be smaller even than those of Air, by their passing through Cork, Glass, and other Bodies, which Air cannot pass through, and consequently their Interstices must be still much smaller.

on of the Particles of Water, should afterwards, when carried to Distances from each other, where their mutual Attraction must be rendered much weaker, forsake the Particles of Water (which they had attracted and joyned themselves to so strongly) come together again, and combine more firmly than they did before *; for Crystals are not near so easy to dissolve as Salts before they are crystalized?

Does not the Power of Attraction increase as the Distances between the Particles decrease? Is it not of great Strength, when they are brought in Contact? and would not most Bodies be absolutely solid, and their Parts almost inseparable, was not Hardness an essential Property in Matter, which (by rendering the Particles incompressible) prevents their Contact otherwise than in Points, and occasions numberless Pores or Interstices between them?

May not the attractive and repulsive Power be in proportion to the Surface rather than the Solidity, (as it is found in Magnets,) and in Consequence thereof, are not the smallest Particles indued with the strongest Attraction and Repulsion?

If

*When a Glass Tube, made Electrical by rubbing, attracts a downy Feather, soon afterwards repels it, and drives it continually away until the Feather has touched some other Body; after which it immediately attracts, and then repels it; have we not a plain ocular Demonstration of alternate Fits of Attraction and Repulsion?

If the Particles of Matter have Sides and Angles, will they not touch in more Points, and form Bodies more solid and durable when joyned together laterally, than when connected by their Angles? And if the Surfaces of such Bodies are smooth and polished, will not their Junction be much the firmer?

When one Salt is said to be converted into another, or appears in the Figures of another, by the Addition of something thereto; may it not be supposed, that by the Intervention of other shaped Particles, the Particles of the first Salt are prevented from cohering by the same Sides and Angles as they did before: and that by the Mixture of these Figures the new Forms are produced?—Some Solutions will mix and form Crystals and Configurations by Combination: in others, however blended, the Crystals of each Kind appear always separate.

Are not transparent Bodies composed probably of homogeneous Particles, or Particles of the like Size and Figure, arranged in some uniform Direction, whereby their Interstices being rendered regular, are fitly adapted for transmitting the Rays of Light? And is not the Transparency of all saline Crystals and Configurations most likely to be owing to the same Cause?

Do

Do not the Colours of Bodies also depend on the Arrangement of their Particles, for the more or less ready Reflexion, Refraction, Transmiffion, or Retention of the Rays of Light?

C H A P. VI.

Directions for making a Collection of the Solutions of SALTS and SALINE SUBSTANCES, and preserving them always in Readiness to be examined by the Microscope.

AS the Curious may be desirous to collect and keep by them the several sorts of Salts mentioned in this Treatise, whereby they may at any time amuse themselves or entertain their Friends at a Moment's Notice; I shall put them in a Way that will intirely answer this Purpose, founded on my own Experience.

Let a Drawer or Box be made three Inches in Depth, ten Inches wide, and fourteen Inches long in the Clear: at about an Inch and a quarter from its Bottom place a thin Board of the exact Length and Width of your Drawer, horizontally, on four little Pillars fastened in the Corners; this Board having first of all round Holes cut through it, in Rows, of a Size to receive Glafs Phials that hold one Quarter
of

of an Ounce, and sufficiently large for them to go easily in and out. Such a Board will conveniently admit of twelve Rows, each Row having eight Holes.

Being thus furnished with a Repository for your Collection, and provided with ninety-six Phials of clear Glass to place in these Holes, where they will stand in order without Danger of tumbling down or being otherwise displaced, put into each Phial as much of any Salt or saline Substance, reduced to Powder, as you are certain will be sufficient to saturate about half the Quantity of Water it can contain; for 'tis best to prepare no more at once, as thereby you will leave room for making Mixtures and trying Experiments, which if the Bottles are quite full you cannot do so well. Then with a Tea-spoon, half fill your Phials with boiling Water, immersing them all the while up to the Neck in a Bason of Water, likewise boiling hot †, and hold them there till the Salt is all dissolved, or you are sure the Water will dissolve no more.

This done, fasten with stiff Paste a small Piece of Paper on the Side of each Phial near the Neck, that it may easily be seen; having previously marked the Papers 1, 2, 3, 4, 5, &c. in a numerical Order. Fit
D the

† Cold Water or warm Water will do for some sorts, but hot Water does no Harm to any, and is best for most.

the Phials with good found Corks, on which you must likewise mark the same Numbers, that you may not mistake the Bottles they belong to : and do not think it enough to mark the Corks only, for many of the Salts will destroy the Marks upon the Corks, and by that Means leave you in the Dark as to what they contain, unless there are Papers also marked, to help you out.

Make then an exact Catalogue of them, setting down each Particular under a *Number* correspondent to that on the Bottle it is in ; whereby you will at any time find readily whatever Solution you want to examine. You may range your Bottles in what Order you think fit : that in this Treatise is perhaps as good as any.

These Preparations will keep good many Years ; and when any Phial is almost out it may easily be replenished, so as to preserve your Collection always compleat. You must not expect to fill all your Bottles immediately ; forty or fifty sorts will be perhaps as many as you will soon be able to procure ; and therefore, if you shall be satisfied with them, your Box may be contrived in the above Manner to contain only some such Number. But a diligent Enquirer will be able to add to them from Time to Time, and would not willingly be limited in his Researches. Suppose how-
ever

ever you have only forty Sorts ; by different Mixtures and Compositions of them with one another, you may produce many thousands of Subjects for Examination, and be continually discovering new and wonderful Configurations : from this rich Store, by combining different Salts, and in different Quantities, innumerable Varieties may be formed, as from the different Arrangements of the twenty-four Letters of the Alphabet, all the Sounds of Language may be signified.

Here is an unbounded Field, which I only point out to the Curious, without describing the Beauties I have frequently met with in my Rambles there. 'Tis enough for me to shew the Configurations and Crystals of Salts simply and singly ; I recommend to those who have more Leisure, to examine them all differently combined.

Solutions thus prepared will be always ready to shew the Configurations forming under the Observer's Eye ; a Sight no one can behold without Admiration and Delight. It would likewise be very desirable to preserve the Configurations themselves, after they are compleat and perfect, or in their different Stages : but this in general cannot be done, for much the greater Part of them are broken and destroyed by the Air soon after they are produced. A few however are durable, and may be kept a

long while in good Perfection, if another Slip of Glass, of the same Length and Breadth, be placed over that the Configurations are formed upon, with the Interposition only of a very thin Slice of Cork between them at each End, to guard the Configurations, by keeping the Glasses asunder, from being any ways rubbed or damaged. A little Glew, strong Gum, or sticking Paste, applyed to each Side of the Slices of Cork, will fasten the Glasses so well together as to make of them a sort of Boxes or Cases, including the Configurations and defending them from any Injury, if the open Sides be shut up, by pasting a narrow Slip of Paper over them: but then Pin-holes must be made through the Paper; for if the Air be intirely excluded, the Configurations will soon decay.

I have now by me several of these little Cases of Glass, containing Configurations and Crystals that appear nothing at all the worse for keeping, though they have been prepared at least four Years. These are always ready to shew in a Minute, without any farther Trouble, and are a very pretty and curious Set of Objects. The Glasses for them are all cut by the Glazier of the same Size exactly, *viz.* one Inch and three Quarters long, and almost an Inch broad. They must be free from Scratches, Flaws, or Air Bubbles.

The

The Salts whose Configurations or Crystals may be thus kept, are *common Salt* of some kinds, not of all: *Alum*, some of the *Vitriols*, *Saccharum Saturni*, *Ens Veneris*, *Salt of Amber*, and some others, which are easily known by their not breaking or dissolving away soon after they are produced.

C H A P. VII.

A general Explanation of the PLATES, with some farther Thoughts on the Crystals and Configurations of Salts.

HAVING declared already what I mean by Configurations, and given a full Account how to prepare saline Substances for that Purpose, and to make a proper Collection of them, little more is requisite at present than to explain briefly what the following Plates design.

Each Figure represents a Drop of the Solution of that Substance whose Name it bears; and is calculated to shew the Process of its Appearances, from the first beginning to crystalize about the Edges, to the full and compleat Conclusion of all its several Changes.

As Heat excites Action, and sets the saline Particles in Motion, those Particles, whilst

38 *Thoughts on Configurations and Crystals.*

floating in a heated Fluid, may be supposed to have a considerable Liberty of exerting their attractive and repulsive Properties, as they approach each other in their Fits of Repulsion or Attraction; or according to the fortuitous Apposition or Approach of their attractive or repulsive Points each to other; whence a Commotion must necessarily arise, some attracting and others repelling, till such time as the Particles can dispose themselves in the Order and Figure that must necessarily result from their original Forms and Properties: which Forms and Properties being supposed unalterable, how often soever they are dissolved or separated, they will constantly unite again in the very same Manner *. And accordingly, in many of the following Solutions innumerable little Masses may be discovered, hurrying about most violently, and in all Directions, before there appears the least Tendency towards shooting into regular Figures.

The Solution being more shallow, and the Attraction greater, about the Edges of the Drop than near its Middle, the floating Particles of Salt tend towards the Edges in great Abundance, and begin there, most
com-

* Should the Particles wear away or break in Pieces, the Nature of Things depending on them would be changed. Water and Earth composed of old worn Particles and Fragments of Particles, would not be of the same Nature and Texture now, with Water and Earth composed of intire Particles in the Beginning. *Newton's Opticks*, p. 376.

commonly, to combine in such Crystals as are peculiar to the Subject; the Sides and Angles of which Crystals formed within the surrounding Fluid are regular, polished, and transparent: and their opposite Sides would be the same also, were they not terminated by the Edges of the Drop, and unable to form themselves upon the dry Glass.

This usually is the Beginning of the Process; and thus far the Power of Attraction seems almost wholly to prevail: a Power whereto Crystalization appears almost intirely owing; Repulsion, on the contrary, may be deemed the first Agent in producing Configurations: or to speak more plainly, Attraction, by making all the Particles within a certain Circumference move towards some certain Points, and combine together in a regular Order, produces Crystals; Repulsion, by pushing them outwards from some certain Points, in a regular Order, occasions Configurations, when they are brought together again by Fits of Attraction.

Should it be objected, that our Configurations may also be produced by Attraction only, I must presume to think that is scarcely possible: for the Shoots that first appear do not only push forwards vigorously in the Process, but divide and subdivide into innumerable Lines and Branches; which

Division and Subdivision seem directly contrary to the Effect of an attractive Power ; since Attraction can hardly be supposed to make Particles of the same homogeneous Matter separate. I am however inclinable to believe, that the Fits of Repulsion, which push out the aforesaid Lines and Branches, may be attended or immediately succeeded by Fits of Attraction, laterally, in the Particles composing them ; whereby the intermediate saline Particles dispersed in the Fluid between the said Lines and Branches are attracted to the Sides, combine with, and become a Part thereof. For was it otherwise, when the Fluid is quite evaporated, Particles of Salt would be found between the Lines, which they are not in any Quantity. Such a Propulsion forwards and Attraction sideways, at, or nearly at the same Instant of Time, may easily be imagined, if we suppose two opposite Sides of the saline Particles indued with an attractive, and two other opposite Sides of the same Particles indued with a repulsive Property, in some such Sort, as every Ray of Light is consider'd by Sir *Isaac Newton*, in his Observations on the double Refraction of Iceland Crystal, as having * four Sides or Quarters, two whereof opposite to one another incline the Ray to be refracted after one Manner, and the other two opposite Sides incline the Ray to be refracted after a different Manner.

Crystals

* *Newton's Opticks*, p. 334.

Crystals and Configurations are frequently seen together in the same Drop, and forming at the same Instant. As soon as the Crystals become discernable by the Microscope, they are either Cubes, or Rhomboids, or Columns, or pyramidal, or triangular, or some other certain Figures; and to what Bigness soever they may become enlarged, they shew, from their very first Appearance, the same Sides and Angles that are seen afterwards when at their utmost Size, no Alteration of Figure attending their Increase in Bulk. But the Configurations change their Forms every Moment, pushing forwards in new Shapes continually, and leaving no Resemblance of the Forms that presented first: insomuch, that no better guess can be made (in a Subject never before examined) what Configuration will be form'd thereby, from seeing its first beginning Shoots, than from seeing the Germen or seminal Leaves of an unknown Seed one can pass a Judgment what other Leaves, Flowers and Fruit such unknown Seed shall produce.

From the first pushing forward of the Salt there is a continual seeming progressive Motion and Change of Figure * : but

as

* Notwithstanding this Manner of Expression, in Conformity to the Appearances of Things, I suppose the Configurations of Salts are produced according to certain Laws of Repulsion and Attraction, whereby the floating Particles

cles

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as Motion can not be pictured, I have endeavoured to supply that Defect, by representing, in several Parts of the same Drop, the different Stages or Appearances that are most remarkable during the whole Process, and by giving a particular Account thereof in the Description.

The crystalline Shoots that present about the Edges of the Drop demand our first Examination ; and it is advisable from their very Beginning to keep the Eye constantly fixt upon them, and to observe their Growth. In some Subjects the Configurations push out from these Crystals into an Infinity of regular Branchings; but in others, and those especially of the mineral Kind, the Crystals shooting from the extreme Edges into the ambient Fluid preserve themselves separate and intire, even through all the Changes that happen, and by their Transparency

cles of such Salts become arranged in certain determined Figures, according to their respective Kinds, by Juxtaposition, Accretion or Apposition, and not by any Protrusion or shooting forwards in the Manner of the Growth of Plants. And therefore though *growing, shooting out, branching, protruding*, and such like Terms, are frequently made use of in the Course of this Treatise, in order to avoid Circumlocution, and to render the Subject more familiar; the Reader is desired to take Notice and remember, that such like Expressions are not to be understood literally in the strict Sense of the Words, as supposing any thing similar to Vegetation; any more than among People well skill'd in Astronomy the Sun is supposed actually to move from East to West, to rise in a Morning and to go down at Night, though they frequently speak of its moving so, of its rising, and its going down, in conformity to common Appearance.

sparency and polished Sides and Angles, bear a near Resemblance, when enlarged by the Microscope, to the Shootings (in the Fissures of Rocks and Mines) of Spars, Crystals, and several Kinds of angular and figur'd Gems, and serve moreover to point out after what Manner such Bodies are also probably form'd in a surrounding Fluid *, and possibly too of similar Materials: for there seems nothing unreasonable in supposing, that different mineral Salts, dissolved in some Fluid exuding from Rocks or Mines, and tinged with metalline Matter, may, through the wonderful Chemistry of Nature, supply the different Substance, Hardness and Colour of Spars, Crystals, and precious Stones; in some such like Way as their Resemblances are produced from the Solutions of such Salts †. Nor are the Hardness of precious Stones, their being void of any saline Taste, and their

* Crystals and all angular Bodies congregate in the Middle of a solvent Fluid or Menstruum. The Fluid wherein Crystal is congregate, is to Crystal as common Water is to Salt. (*Steno's Prodromus*, Eng. Edit. Page 64.) That is, the Crystal Particles are separated and float in such Fluid, as the Particles of Salt do, when dissolved, in common Water.

† Mines, or Beds of Metal, are met with constantly, if sought after, near the Places where precious Stones are found. The Ruby is supposed by some to take its Tint from Gold, by others from Iron; the Emerald and Sapphire from Copper, but by different Menstrua; the Topaz from Lead or Iron, Granates from Iron, &c. and a Mixture of two or more Tints from different Metals may possibly give Colour to the Amethyst, the Hyacinth, the Opal, &c. A greater or less Proportion of metalline Matter may also render the Gem deeper or paler, harder or softer.

When

their Indiffolubility, fufficient Objections againft Salts being the Bafis of Diamonds, Rubies, Emeralds, Granates, &c. fince it is obfervable, that Glafs, in whole Compofition Salt is a principal Ingredient, proves alfo undiffolvable, is indued with a confiderable Degree of Hardnefs, and (as its component Salts cannot act unlefs diffolved) is confequently infipid, or rather abfolutely taftelefs.

Whoever fhall pleafe to repeat thefe Experiments after me, will I believe be fatisfied, that the Cryftals fhooting from a Solution of diftilled Verdigreafe, which is a Vitriol loaded with Copper; thofe Cryftals I mean whole Roots are at the Extremity of the Drop, and their Points in the ambient Fluid, refemble nearly the fhootings of Emeralds both in Figure and Colour: that the Cryftals of *Ens Veneris*, a Preparation of Iron, wonderfully emulate the Topaz, &c. No

When the faline Particles combine, without any metalline Admixture, the Concrete appears colourlefs, and probably forms pure Cryftals or Diamonds. The extreme Hardnefs and Luftre of the Diamond refult perhaps from the almoft abfolute Homogeneity and Purity of its component Particles; whole Sides or Planes having admitted no foreign Particles between them, touch in many Points, and become thereby almoft infeparable. Saline Particles in fuch Purity meet, however, but very feldom, and in fmall Quantity: but as mineral Salts abound almoft every where, and efpecially about Rocks and Mines, they frequently appear in Shoots or Maffes, blended more or lefs with talcky or other Matter, and probably conftitute our Cryftals, Spars, &c.

No Kinds of Matter that we know of, except Salts, have a Tendency to such-like Figures : but Salts when at Liberty always appear in them. The Transparency of Salts is also another Property almost peculiar to themselves and the Bodies we are supposing them to compose : and therefore, notwithstanding in these our hasty and imperfect Experiments the Shoots are so minute as to require a Microscope to discern them, and so tender that the Air in a short Time destroys them, may not Nature, who proceeds surely though slowly, produce Bodies from a better Combination of the same Kinds of Materials, of Size proportionable to the Quantity of such Materials, similar in Figure and Colour, hardly separable and of long Duration ?

I have dwelt the longer on this first Part of the Process (which the Drawings point out in the Shootings of *distilled Verdigrase*, Plate II. 1, 1 : in those of *Alum*, Plate III. *b b* : and of *Ens Veneris*, Plate IV. *a a*) since every Observer must be highly pleased, to behold the beautiful Appearances of Emeralds, Diamonds, &c. rising as it were from their native Bed, forming their regular Sides and Angles under his Eye, and glittering with a Brilliancy and Colouring hardly to be imagined.

What has been hitherto described regards the Figures only that proceed from
and

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and seem rooted to the very Extremity of the Drop.---The detached Crystals that appear forming within the same come next under Examination : and these, from their very first becoming discernable, being encompassed on every Side by a Fluid replete with saline Particles, (which, swimming at Liberty, are attracted or repelled from every Quarter, till the Points of greatest mutual Attraction meeting in Contact, combine according to their respective Figures†:) These, I say, have all their Sides most commonly regular and compleat, with such Number and Disposition of polish'd Planes and Angles as fully distinguish from what Salt they are derived.---These are the Crystals that were before mentioned to retain their Figure however their Size enlarges : They, and they alone, are properly to be termed the Crystals of such Salt, and many of them in Elegance of Form and native Lustre excel the Workmanship of the most expert Jeweller. These are intended to be represented in the *Alum* Solution at *f*, and in that of *Ens Veneris* at *b b*. They are also shewn again by themselves, and in a larger Size, under those and some of the other Drawings.

After

† All fossil Crystals, Gems, and other Bodies that have regular Planes and Angles, without an Appearance of being broke off from any Root or Stem, are probably formed in the same Manner.

After the Crystals about the Edges are grown large, and those farther within the Drop have likewise pretty nearly attained their full Size ; in the Solutions I mean where such Crystals do form ; for several Kinds produce Configurations but no Crystals ; and, on the contrary, in some few, *viz.* of Sal Gem, common Salt, &c. though abundance of Crystals are produced, no Configurations at all appear : After, I say, the Crystals are formed, the Configurations begin to shoot, proceeding somewhat slowly at the first : but they quicken by Degrees, and dart at last, in many Subjects, quite over the whole Drop, as swift as Lightning ; and that especially if the Drop has been too much or over suddenly heated. Therefore when the Configurations once begin, the Eye should never be taken off, till they are intirely finished. Some Description of them is given under each particular Subject, and they are represented in the Drawings, as the third Stage of the Process, signified by *c*, D, *e*, F, G, in the Alum Drop, and by *c* and *d* in the Drop of *Ens Veneris*.

These Configurations are no less constant in their Forms than the Crystals are, insomuch that each Subject is easily distinguished by them. They seem composed likewise of the same transparent shining Particles : but the Figures they produce
are

are so extremely different, that every considerate Observer must judge them owing to some very different Property in Nature.-- I have ventured to mention Attraction and Repulsion, as two Principles that we may suppose concerned in producing these different Appearances, but am very far from being obstinate in this Opinion, or unwilling to recede from it, whenever any more probable Cause can be assigned. I am sufficiently sensible how liable we are to be mistaken, and how very little we know even of the most common Things. The very Elements that are continually about us, the Fire, the Water, the Air we breathe, and the Earth we tread upon, have many Properties beyond our Senses to reach, or our Understanding to comprehend: and when we imagine we know any one thing perfectly, I am afraid we flatter and deceive ourselves very grossly. It is our Happiness, however, and our Duty, to bestow some Time and Pains in making ourselves acquainted with the Productions and Changes that Providence continually brings about in a regular and constant Manner. We are able to see Effects, though their Causes are beyond our Knowledge: but as no Effect can be produced without some Cause, when we behold Order, Harmony, and Beauty arise out of Confusion, by means of certain active and unalterable Properties, where-

wherewith the Author of Nature has indued the original Particles of Matter; though we cannot understand the mechanical Operation of these Properties, or know really what they are or can perform, we should raise our Contemplations and Adoration to that Eternal, Omnipotent, Supreme First Cause, who is incomprehensible in all his Works: and here, perhaps, here only, our Ignorance may commendably become the Mother of our Devotion.

In short, if the Crystals of saline Substances are wonderful, their Configurations are infinitely more so: their Variety and Beauty no Words or Language can possibly express; and trying to give the Pictures of them is like endeavouring to paint the Lustre of a Diamond, or the Brightness of the Sun-shine.

It happens in some Kinds of Solutions, that after the first Crystals are formed, the Configurations perfected, and when every thing seems over, and all is quiet, other new Configurations, and Crystals too, present themselves, in Figures very different from the former, and what probably are owing to Salt of another Kind that was latent in the Mixture.

C H A P. VIII.

Of Gem-Salt, Sea-Salt, and Spring-Salt.

G*EM-Salt* dissolved in warm Water, and a Drop applied to the Microscope on a Slip of Glafs, either holding it over the Fire for a little while to hasten the Experiment, or leaving the Water to evaporate at leisure, affords the several Figures that appear in the first PLATE N° I.

Sea-Salt treated in the like Manner produces Crystals as at N° II.

The Figures of *Spring-Salt*, or * *Basket-Salt*, obtained by the same Method, are shewn at N° III.

The Figures of these three Salts differ very little ; each of them producing Bodies of the like Forms ; *viz.* solid Cubes, square Plates, and hollow Pyramids, having Bases that are either exact Squares, or Rectangles, and whose sloping Sides diminish gradually upwards by a kind of Steps, some terminating in a Point, and others appearing truncated, or ending with plane Surfaces. Each Kind of these Salts does not however produce the same Figures in equal Plenty, for *Gem-Salt* affords most Variety ; *Sea-Salt* abounds chiefly with those

* This does not mean that all Salt made from Springs is *Basket-Salt*, but only that our *Basket-Salt* is one kind of Salt made from Springs.

those two Figures at N° II. and *Spring-Salt* with those at N° III.

Most Writers represent the Crystals of these Salts as Cubes ; and such in Truth they seem originally to be : I mean when so minute as just to become distinguishable by the greatest Magnifier : large Masses of *Sal-Gem*, and sometimes of *Sea* and *Spring-Salt* are seen in cubical or rectangular Figures, made up without doubt of innumerable minute Cubes. But in all Examinations by the Microscope of the Solutions of these Salts, the Bodies that form and grow under the Eye are, in the general, not Cubes, but hollow Pyramids : though a Prepossession that the Crystals of such Salts are Cubes, makes these Figures, even under Inspection, often imagined so to be : for the square Out-line, which is only the Base of an hollow Pyramid (if great Attention be not employed) is apt to give the Idea of a Cube : and the different Ranges or Steps, which by a gradual Diminution upwards compose the sloping Sides of the Pyramid, are easily mistaken, from their great Transparency, to be no other than Lines upon the Surface of the Cube. Indeed a few Cubes are seen now and then amongst the other Forms, but their Number is far too small to conclude the general Figure from : those very Cubes in some Positions have

likewise the Appearance of regular Hexagons, as in PLATE I. N^o I. 1.

I have examined various Species of these Salts from different Parts of the World, and particularly several brought from *Egypt, Hungary, Germany, &c.* by my worthy and ingenious Friend Dr. *Richard Pocock*, Archdeacon of *Dublin*, and F. R. S. which tho' red, brown, white, &c. and seemingly of very different Contexture, some appearing fibrous, others sparry, talky, &c. yet when dissolved and examined, much the greatest Part of the regular Bodies produced in them all were of the same general Figure, *i. e.* hollow Pyramids; with little farther Difference, than that some were more transparent and sharper at the Top than others. It may therefore reasonably be concluded, that an hollow Pyramid, either pointed or flat, is the general Figure of all *Fossil, Sea and Spring-Salts*, when after being dissolved, and a small Degree of Heat given, their Particles are brought together, and unite again according to the Order and Disposition of Nature: which hollow Pyramid is composed of minute Cubes most regularly and wonderfully combined*. And this has been demonstrated
even

* Dr. *Brownrigg* observes, in his very curious Treatise of the *Art of making Common Salt*, p. 67. That when by a very gentle Exhalation of Water from common Salt, it is

even to the naked Eye by the Salt made after Mr. *Thomas Lowndes's* new Method, where Multitudes of such regular pyramidal hollow Bodies may be found, composed as it were of a Number of little Stairs; and so large, that each Side of their square Base is at least a Quarter of an Inch in Length †.

None of these Salts afford any Branchings out: the Appearances round the Edges of the Drop, when Heat is apply'd, being nothing else but a Congeries of saline Particles hurried together with very little Regularity, and producing no new Forms; for which Reason these Combinations are not represented in a Drop, as all that shoot into Figures more different are. But notwithstanding the general Shape of these Bodies is nearly the same, there are particular Differencies very well worth observing, which the *Drawings* endeavour to express.

E 3

PLATE

is suffered to shoot into its true Form, its Crystals are found of a cubical Figure of various Sizes: and many of these smaller Crystals are united together into hollow Pyramids with a square Base. These Pyramids are truncated, being not finished at the Top, but having there fixed a Cube of Salt of a more than ordinary Bigness.

† Mr. *Lowndes* says, "in the Salt made by the Sun, as well as by my Way, you will never fail of seeing very many little Pyramids, which are composed of a Parcel of small cubical Grains, piled up in a most exact Order, and cemented together with wonderful Nicety: and the Crowns of these Pyramids are always Cubes of a much larger Size than any of the Rest." Vid. *Brine Salt improv'd*, p. 16.

P L A T E I. N^o I.*Figures of SAL-GEMMÆ, or ROCK-SALT.*

- a* - A square pyramidal hollow Body, somewhat opaque, whose four Sides are sloping Triangles, and meet in a Point at Top.
- b* - A Body with four equal sloping Sides, terminated by a Plane at about half the Height of the former: not much transparent, but hollow.
- c* - A Body rising about the Height of the last, in the Manner here shewn, and very transparent, except as the Lines imply.
- d* - A square thin Plate, exceedingly transparent.
- e* - An hollow Pyramid, whose Base is a Rectangle, and whose Sides are sloping and terminate in a Point; the whole semi-transparent.
- f* - A narrower hollow Rectangle, with sloping Sides not much transparent, rising about half as high as the preceding, and then ending in a flat Surface that is very transparent.
- g* - Another hollow Figure, having a rectangular Base, very transparent, with sloping Sides as in the Picture.

b—An

- b* - An hollow Body, whose Top is a large transparent Square, and whose Sides are darkish in the Middle, but very transparent at the Ends, whereby the four Corners become also transparent.
- z* - A very pretty transparent truncated pyramidal Figure, whose Top is also a transparent Square, and whose four Corners appear to open and separate.
- k* - A solid Cube, semi-transparent.
- l* - Another Cube, which by its Position, if carelessly examined, will probably be mistaken for an Hexagon.
- m* - A square Plate of some Thickness, but transparent: its Situation makes it seem a Rhombus.
- nn* - Two oblong Plates, extremely thin and transparent, with a Spot in the Middle of each.

PLATE I. N° II.

Figures of SEA-SALT.

- o* - A square Pyramid, hollow, and pretty transparent, wherein a Kind of Steps appear gradually lessening upwards.
- p* - Another Figure about half the Height of the preceding, whose Top is a very transparent square Plane, and whose four sloping Sides are graduated and considerably transparent.

P L A T E I. N^o III.*Figures of* SPRING-SALT.

After the Descriptions already given, 'tis needless to say more of the four following Figures *q, r, s, t*, than that they also are hollow pyramidal transparent Bodies, with such different Graduations as themselves pretty tolerably represent.

v, w—Two of the large hollow Pyramids of Mr. *Lowndes's* Salt, drawn in such a perspective View as may best express their real Figure; each having a square Base, and four triangular Sides that are nearly equal. Many fine Lines appear running across these Sides parallel to the Base, which on a strict Inspection, are found to be a regular Graduation of Steps, lessening from the Bottom upwards. These Pyramids do not commonly end in Points, but are terminated by a cubic Figure: each Corner of their Base is also frequently supported by a Cube, but of a smaller Size; and still lesser Figures of the same Shape appear along the linear Edges, in number equal to the Steps, and closing the Angles where they join. There are Graduations within side these Pyramids correspondent to those without, like the Underwork of a Pair of Stairs. The Size here exhibited is
but

is but little larger than that of the real Bodies they were drawn from.

It is very well worth remarking, that amongst the many pyramidal Figures presenting themselves in a Drop of the Solution of these Salts, every one seems to stand erect upon its hollow Base, and appears, when under Inspection by the Microscope, exactly in the same Manner represented in the Plate : but this is a Deception; for in double Microscopes compounded of three convex Glasses after the usual Manner, all the Parts of an Object are seen inverted; that is, the Top appears at Bottom, the left Side on the right, &c. The Lights and Shades being also inverted, the sinking Places appear to rise, and the rising Places to sink in: so that in Truth the hollow Base of the Pyramid is really uppermost and next the Eye, tho' it seems to be quite otherwise. And in Confirmation of this, I was assured by Mr. *Lowndes*, that in the making his Salt, nothing is more common than to see the Pyramids forming upon the Surface of the Brine, and always with their truncated Ends downwards*.

We

* We are told in the *Memoirs of the Royal Academy of Sciences* for the Year 1700, that Monsieur *Homburg* shewed a little Pyramid of Salt, formed in a Crystallization. It was but low in Proportion to its Base, hollow within, and its Base was uppermost during the Time of its Formation; which Monsieur *Homburg* thus accounts for. There was formed, says he, at first, a little Cube of Salt (the Figure Salt naturally affects) on the Surface of the salted Water.

This

58 *Salt whence derived, and how diffused.*

We begin our Experiments with that native fossile Salt, usually called *Rock-Salt*, from its Place of Growth, and from its Clearness *Sal-Gem*; as it is probably the Principle or Basis of several other Salts.

Sea Water owes its Saltness most likely to vast Quantities of this Salt dissolved therein; which, being extracted by different Methods, becomes either *Bay-Salt*, or what we commonly call *Kitchen-Salt*: and Springs running through or over Beds thereof, and becoming saturated therewith, afford by Boiling and Evaporation all our Inland or
Basket-

This Cube did not sink, though heavier than the salt Water, any more than a Needle if laid on Water gently would do, and for the very same Reason; for when a Needle is placed in such a Manner on Water, a little Hollow is made about it, filled with Air only, in which it lies as in a little Boat; because the Bulk of the little Hollow and Needle together is lighter than Water of the same Dimensions. A similar Hollow was formed about this Cube of Salt, which entered a little into the Water without sinking; its upper Surface was dry, and rose above the Surface in the Hollow, though not so high as the general Surface of the Water round it. Other Cubes of Salt crystalizing along the four Sides of this dry Surface began to form a small hollow Square, of which the first Cube composed the Base. These little Cubes when joyned together, becoming heavier than the first single one, and being encompassed with less Air in Proportion, from their Junction to the first by their inner Sides, sunk still deeper in the Water, that is, to the upper Surface of the little Cubes which adhered to the first Cube. New Cubes of Salt adding themselves to these sunk the Body yet lower down, and others continually joyning them after the same Manner, by enlarging the hollow Square, still plunged it more and more, and formed the inverted Pyramid; which growing at last too heavy, sunk to the Bottom of the Water, and then increased no more.

Basket-Salt ; so that, in Reality, *Rock-Salt*, *Sea-Salt*, and *Spring-Salt* are derived from one and the same Original in the Bowels of Rocks and Mountains ; and upon the strictest Examination, they seem to differ no otherwise than by some adventitious Mixtures, as our Experiments evince, by shewing that neither of them form any branched Configurations ; but when their Particles combine again after Dissolution, they constantly compose the same Kinds of pyramidal Crystal Bodies, with Bases that are either exact Squares with four equal Sides, or else having two opposite Sides longer than the other two, but always making a right-angled Figure.

This Salt is conveyed by Springs and Rivers where-ever their Waters can find a Passage. Its finest Particles rising with Exhalations from the Sea and other Waters, are likewise dispersed universally, and saturate the Surface of the whole Earth : where entering the Roots of Plants they promote Vegetation, help to compose their solid Parts, ascend with their Juices, and, according to their Mixture with them, produce that amazing Variety of Tastes, Smells, and other Qualities. Some of this may be recovered in its original Form by Art from most Kinds of Vegetables, while the rest becomes so changed by being blended with other Substances, as to appear in the Shoots
or

60 *The Nature and useful Properties of Salt.*

or Crystals peculiar to each Sort of Plant, and probably constitutes its *essential Salt*.

It is also taken continually into the Stomachs of Animals, their Food abounding with it, and affording them proper Nutrimēt by the Means thereof. It dissolves in and circulates with their Blood and Humours, and becomes so highly subtilized by the Heat and Action of an animal Body, that the greatest Part of it is rendered volatile, and can hardly be reduced again into its original Figure, though some of it may always be found unaltered in the Blood, Urine, &c. And the Fertility which Dung produces in barren Soils is owing to the Abundance of it contained therein: for though Salt in its natural State is prejudicial to Vegetables, it becomes so tempered after having passed through the Bowels of living Creatures, and been intimately mingled with their putrifying Fæces, that it causes them to thrive exceedingly.

No Menstruum is yet found to dissolve Gold, unless one of the Salts we are treating of be an Ingredient therein; they being the only known Dissolvents of Gold, as Nitre is of Silver: but on the contrary, Common Salt, Rock-Salt, or Spring-Salt, mixed with *Aqua Fortis* or *Spirit of Nitre*, will prevent its dissolving Silver, though such Mixture proves the readiest Dissolvent of Gold.

The

The Nature and useful Properties of Salt. 61

The peculiar Excellence of these Salts for the Preservation of Flesh, Fish, &c. is too well known to need Description; and their other extraordinary Virtues, when prepared in different Ways, are too many to be mentioned here. *Glauber* asserts, that common Salt is the most useful and most excellent of all the rest, being the Principle whence all other Salts, either known or unknown, are chiefly derived, and may by Art be produced. By a little Labour and Fire, and the Addition of some metallic Sulphur, it may, he says, be converted into Alum or Vitriol; by Fire, Air, and Sulphur, into Salt-Petre; by the Help of a fiercer Fire, into an alkalious Salt, and by destroying its Acridity, into a Salt fit for enriching Land, and extremely serviceable to sandy and barren Soils †.

Common Salt dissolved in sharp Vinegar, and a Drop thereof a little heated, shoots some pretty Configurations from the Edges, and affords Crystals of the Figures just now described, extremely clear and beautiful, though smaller than usual. These frequently are joyned together with a curious Variety of Composition, which the Crystals of the same Salt dissolved in Water never exhibit, for they commonly form separate and disposed at Distances each from other.

Diffolved

† Vid. *De Nat. Salium*, Amstel. p. 49.

Dissolved in Spirit of Wine it likewise produces Configurations, but very different from those in Vinegar, with Crystals smaller than ordinary, and having little or no Transparency.

Dr. *Boerhaave* says, these three Species of Salt dissolve alike in three Times and a Quarter of their own Weight of Water * : but I have found a considerable Difference in different Waters, and in different Portions of the same Salt.

C H A P. IX.

NITRE, *or* SALT-PETRE.

THIS Salt being dissolved in Water, a Drop of the Solution shoots from its Edges, with very little Heat, into flattish Figures of various Lengths, exceedingly transparent, and with Sides that are strait and parallel. These are shewn in their different Degrees of Progression, at the Letters *a, b, c, d, e*, Plate I. N^o IV. where *a* represents how they first begin.

Many of them appear cut sloping at the Ends down to a sharp Edge, in the Manner of a Chissel, and are some wider and others narrower. Several also are found with

* *Shaw's Boerb. Chem. p. 106. Vol. I.*

with one Corner taken off obliquely, and that in different Angles, leaving the other Corner sometimes quite a Point, and sometimes having a little Breadth.

After Numbers of these are formed, they will often dissolve again under the Eye and intirely disappear; but if one waits a little, new Shoots will push out, and the Process go on afresh. These first Figures sometimes enlarge only, without altering their Shape; and sometimes form in such Sort as the Drop represents; but if the Heat has been too great, they shoot hastily into numerous Ramifications, very regular and beautiful, but which we have not attempted to draw, from the great Difficulty of doing it. There seems all the while a violent Agitation in the Fluid, and most commonly towards the Conclusion, a few Octaëdra (composed of eight triangular Planes, or two quadrangular Pyramids joined Base to Base) appear; which belong probably to some other Kind of Salt intermixed with the Nitre: Pyramidal Figures of common Salt are likewise sometimes seen; and of these I have now and then found the greatest Plenty when the Nitre has seemed most white and pure, which I pretend not to account for, unless common Salt has been employed to make it so.

The regular Crystals of Nitre are represented underneath the Drop, greatly magnified

64 *Crystals of Nitre, how obtained.*

nified according to my Method of Examination, though indeed less than what may be found when large Quantities are prepared in the common Way; and consist of six parallel Sides or Planes, which compose Bodies of different Lengths, and differently terminated at the Ends. There is also a considerable Variety as to the Equality and Inequality of these six Sides. The most common Crystals are somewhat flat, and have two broad parallel Planes opposite to one another, and four that are much narrower; two of which (*viz.* one that goes sloping from the upper and the other from the under Plane) meet on each Side, and constitute a pretty sharp Edge. One End of these is commonly cut off sloping on both Sides along its whole Breadth, but seldom in the same Angle. *Vid.* Fig. 1. Sometimes however there are four broader Planes, and only two narrower; and now and then the Sides are pretty equal, and their Base is nearly an equilateral Hexagon. The several Differences in the Drawing are likewise to be met with, as well as some others, but the rarest as well as the prettiest is that at Fig. 6.

The best Way to obtain these Crystals for the Microscope, is by saturating some warm Water in a Spoon with Nitre; (not with more however than it can perfectly dissolve) when in a few Minutes little Concretions will

will be seen forming at the Bottom, which being taken up on the Point of a Penknife, before they are grown too large, and placed with a little of the Fluid on a Slip of Glass, will be found, if they are not broken by the Removal, to have amongst them some or all of the Figures shewn in the Drop, and again represented in a larger Manner underneath the same. And though the Crystals thus obtained are exceeding small, they are much more intire, distinct, and true, than what by concreting in vast Quantities become Millions of Times bigger, as they are frequently seen in the Shops. Amongst these too may be found many Crystals perfect at both Ends, by having been formed wholly detached in the surrounding Fluid, whereas those we get by any other Method are almost constantly broken at one End, from their having been fixed thereby to the Side or Bottom of the Vessel they were formed in, or else to one another.

P L A T E I. N^o IV.*[The Crystals of Nitre.*

1. The most common Figure of *Nitre-Crystals*, with one End broken off.
 2. A Crystal with both Ends perfect : one in the usual Form as above, the other
- F
- cut.

- cut off more obliquely, and composing an hexangular Plane. The Sides of this Column are four broader and two narrower Planes, whereas the preceding consisted of two broader and four narrower.
3. Another Crystal, having one End a great deal sloping and graduated, and the other cut off at different Angles.
 4. A Crystal inclosed seemingly within another, and forcing its Way out, by bursting through the other's Side.
 5. A Column with six equal or nearly equal Sides: one End broken, and the other forming an hexangular Pyramid, whose Sides are correspondent to those of the Column.
 6. A short hexangular equilateral Column, both whose Ends are Pyramids, having Sides that correspond with those of the Column.

One Particularity in Nitre is, that its Crystals are perforated from End to End *, all along, just within the Corners where the Planes intersect; as may be proved in the larger Shoots, by the Breath's passing thro' them easily on blowing. These Channels are pointed out in Figure 2, by the six Dots at its End; they are likewise shewn more perfectly at Fig. 7, which represents
part

* *Gugliel. Disc. sopra le Fig. de'Sali*, p. 12.

part of a Column with Hairs passing thro' its Perforations.

This Salt is found just under the Turf about *Patness* in the Northern Parts of the Kingdom of *Bengal*, and probably in other Places thereabouts, whence it is brought to us in great Abundance by the *East-India Company** : but all produced in *Europe* appears either like a kind of Efflorescence adhering to Rocks and Walls, being what the Ancients called *Aphronitrum*, and what is called by us *Natural Salt-Petre*, of which the Quantity collected is but small; or is else extracted by Art from certain Earths and Stones, the Ruins of old Buildings, the Dung of Pigeons, and the Excrements and Urine of other Animals : the Manner of doing which is related by several Authors.

Examined chemically (and to use the Chemist's Terms) it appears compounded of a volatile acid Spirit, and a fixt alkalious Salt. Such a Spirit the Air abounds with : and this Spirit by penetrating into, and becoming incorporated and fixt by the alkalious Salts of Lime, and some Sorts of Earth and Stone, is probably the active Principle that produces *Salt-Petre*. It is also very likely owing to the same Principle, that *Salt-*

* Vid. *Woodward's Method of Fossils*, p. 36.

Petre may constantly be obtained from the Mortar and Rubbish of old Walls, which have been long exposed to the Air; and that the same Materials, after being divested of it by Art, will afford a farther Quantity by lying a few Years together. The extreme Hardness of the Mortar in some old Buildings, where it is found more difficult to be broken than even the Bricks or Stones it served to cement, seems likewise occasioned by its being so fully impregnated with this Spirit † or Principle, that it becomes in a manner petrified: and the alkalious Salts wherewith the Excrements of Animals abound, serve probably, in the like Manner, to fix and embody the same Spirit, and constitute *Salt-Petre*. Some have undertaken to make it likewise from Lime, Pot-Ashes, &c. but howsoever it be produced, it may always be distinguished by its hexagonal Shoots.

Let us now consider what other Productions of Nature appear in this hexagonal Figure; and we shall find that all Crystal, unless either straitened for Room
 or

† May not what we call a volatile Spirit consist of Particles exceedingly minute, and of some determinate Figure; whose Property it is to repel each other, from certain Points, in certain Directions, and to certain Distances; whereby they are unable to combine together, unless by penetrating, mixing, and becoming embodied with other Matter, whose Pores they can strike into? and may not their repulsive Power be increased by Heat or Motion?

or overcharged with foreign Matter, is constantly formed into Pyramids of six Sides, or into hexagonal Columns terminated with such Pyramids, and resembling the Nitre Shoot 5. And as these Crystals shoot most commonly from Rocks of calcareous Stone, may not their Form be owing to the same volatile Spirit, more strongly fixed and embodied, and composing a more hard and transparent Substance, by an Admixture with some Matter different from that where-with it composes Nitre? And if, instead of exsuding from Stones, and adhering thereto by one End, usually called a Root, these Principles happen to concrete in some Fluid, or other soft Bed, where both Ends are equally at Liberty to fashion themselves according to the Inclination of their component Particles, may we not suppose they may then produce * those sparry or crystalline Pyramids, joyned Base towards Base by the Intervention of an hexagonal Column, which are known by the Name of *Buxton Diamonds*, from the Place where found most plentifully; and which in Figure resemble exactly the Shoot of Nitre 6?

The next most remarkable Bodies of this Kind of Figure are those of Snow, which

F 3

are

* Vid. *Woodward's History of Fossils*, vol. I. p. 161. These Bodies are called *Irides* by *Aldrovand*. See his *Museum*, p. 941, 942.

70 *An universal volatile acid Spirit,*

are always hexangular, or with six Points *, nearly resembling the Base of the Column of Nitre 1, or thin Slices of such a Column cut off transversely: and as freezing is usually imputed to the Redundance of Nitrous Particles in the Air, those who embrace that Opinion will probably find little Difficulty in supposing this Form of Snow occasioned by the same Principle that gives an hexagonal Figure to Nitre: and perhaps they are not mistaken in such a Supposition, though there is some Reason to believe they may be so as to the Abundance of the Particles of Nitre they imagine existing in the Air.

The continual Perspiration of growing Vegetables, the Putrefaction and Dissolution of those that perish over the Face of the whole Earth, all which abound with volatileacid Salts; the continual Exhalations from Seas, Lakes, Rivers, and other Waters, which carry also up with them abundance of the finest Particles of Mineral or Sea Salts, the Steams and Vapours from Metals and other Substances, all these compose together the volatile acid Spirit wherewith the Air is filled, and which probably is the active Principle that gives the Figure, and supplies Part of the Matter to Crystals, Snow, and Nitre.

But

* The Flakes found now and then with twelve Points, are probably two Flakes, whose flat Surfaces are stuck together, with their Rays alternately disposed.

But the Particles of this acid Spirit are no more the Particles of Nitre, than Nitre is the Gunpowder which it composes by the Addition of Sulphur and Charcoal. And the Truth of this seems confirmed by the Impossibility of obtaining a single Grain of real Nitre from any Quantity of Snow or Ice: whereas Nitre being but little volatile, some of it certainly would be found if it was really there. However, though no Nitre can be found, after the volatile Salts that link'd the Particles of Water to one another are driven out by Heat, and the Water becomes fluid, it is observed to be much harder, or less fit to make a Lather with Soap, than it was before its being frozen, from its retaining some small Portion of the acid saline Particles, in the same manner as any Water may be rendered *hard*, by putting into it a few Grains of common Salt, or a few Drops of any acid Spirit.

'Tis probable these acid Spirits are produced every where; but being extremely volatile, and easily driven away by Heat, they soon become dissipated in those hot Regions, under, or nearly under the Sun's direct Rays, unless they are immediately embodied by mixing with some other Matter; and consequently, those Countries nearer the Poles, whereto they are driven by the Sun's Heat, must abound with them, more or less, in proportion to the Ability or

Inability of the Sun's Rays to drive them again from thence : and these extremely minute and active Particles, being continually in Motion, strike into, penetrate, and fix between the Pores of all Bodies capable of receiving them. Thus, mixing with saline Exsudations from, or certain Salts contained in Earths, Stones, &c. they may probably incorporate therewith, and concreate into the hexagonal Shoots of Crystal : filling up the Interstices of Water, and becoming therewith embodied, they compose that hard Substance we call Ice † ; which differs nothing from Crystal in Clearness, and perhaps would have the like Form, did not the Quantity and Situation of the Fluid prevent it ; since we find that Water, falling in small Drops, is concreted with the same Particles into an hexangular Figure.

These Particles striking into the Bodies of living Animals occasion the Sensation of Cold : if their Quantity be great, they produce first a severe Pain, and then a Numbness, by impeding the Circulation of the Animal Fluids ; and if they are not driven away by Heat from Motion or otherwise, or their Quantity be much increased, they stop the Circulations intirely, and bring on certain
Death :

* The freezing or sudden Change of Water into Ice, gives the best Idea, how Crystal, Gems, &c. may be form'd, and that too perhaps in a very sudden Manner.

Death : and animal dead Bodies frozen become as hard as Stone. Hence it appears, that freezing is not the Result merely of the Absence of Heat, but is really owing to some active and penetrating material Principles, which by mixing with other Bodies become thereby fixt : and the Existence of such Principles in the Air is farther apparent from the rusting of Metals, the Erosion of Stone, Glafs, &c.

The Supposition that *Salt-Petre* is compounded in great measure of this same volatile acid Spirit existing in the Air, is strengthened, not only by the manner of its Production, but also from its striking the Tongue, when tasted, with a pungent Sensation of Cold, like what this same Spirit in the Air gives : Moreover, a volatile acid Spirit may be obtained from it in considerable Quantity, whose Particles are so active and powerful, that they penetrate, disjoin, and separate the component Particles of all Metals except Gold, as well as Stones and most other Bodies.

Supposing such Spirit one of the chief Principles of *Salt-Petre*, may not its exceeding Volatility, when suddenly and violently excited to Action, by the Fire contained in Sulphur kindled by Charcoal, produce all the prodigious Effects of Gunpowder * ?
and

* Vid. *Quercus*, p. 26.

and also by certain Mixtures in the Air, become the Cause of Thunder, Lightning, and other wonderful Phænomena?

The foregoing Conjectures, into which I fear I have been led too far by my Subject, may 'tis hoped be forgiven, as they are submitted intirely to the Consideration of better Judges, without the least Design of imposing them on any one.—But to return to the known Properties of *Salt-Petre*.

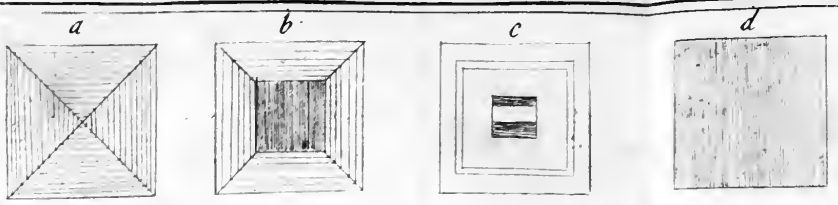
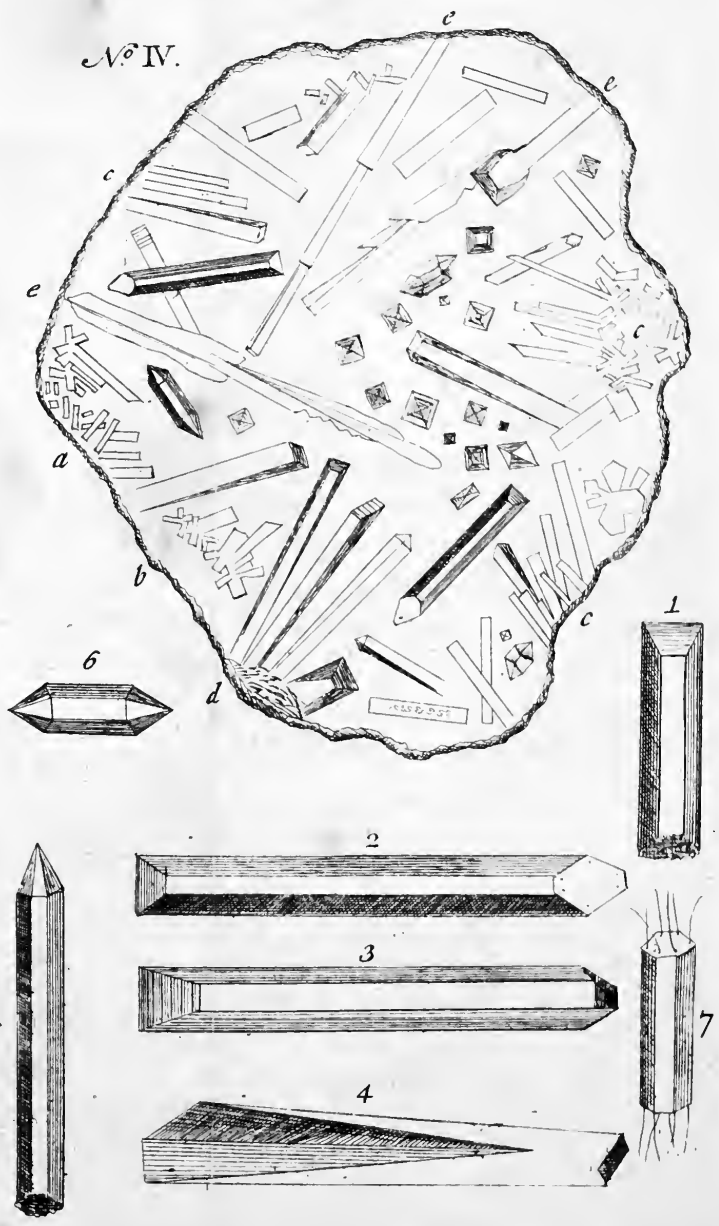
It is said to be the only Dissolvent of Silver, as Sea-Salt is of Gold: for Silver is dissolvable in no Menstruum yet known, unless there be Nitre in it; and yet if Salt be added thereto, the Mixture will no longer dissolve Silver but Gold. It preserves the Flesh of Animals from Putrefaction as well as Sea-Salt, and has the singular Property of giving it a red Colour *. In Distillation also, the Fumes that arise from Nitre are red.

CHAP.

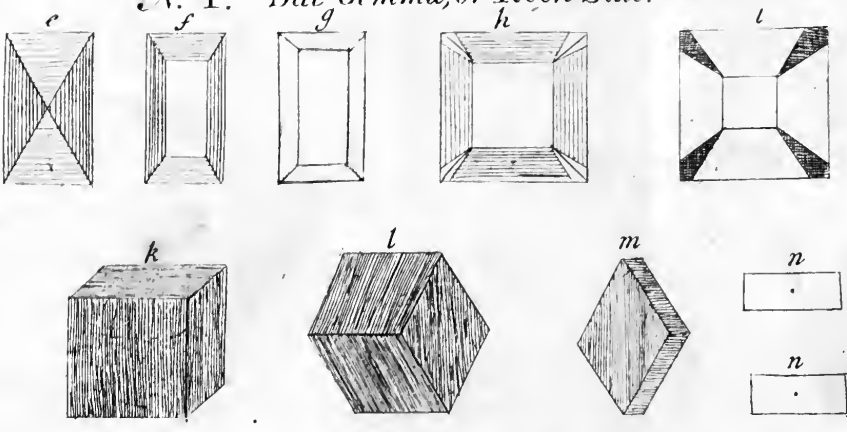
* The Roots of Madder mixed with the Food of Animals tinges their Bones of a curious Red. Vid. *Philosoph. Trans.* N^o 442, and 443, where Experiments in Proof thereof, are given by Mr. *Belcher*, F.R.S. The same is likewise confirmed N^o 457, by farther Experiments made by *Monf. Du Hamel du Monceau*.

Niter or Salt Peter.

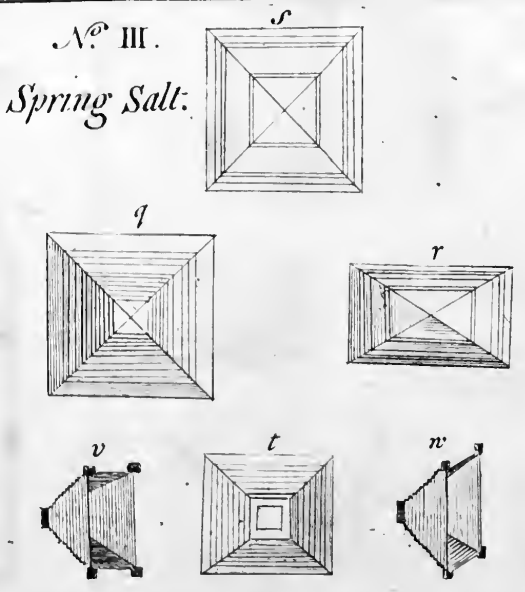
N^o IV.



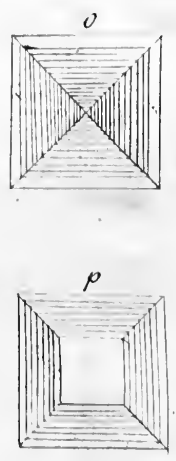
N^o I. Sal Gemma, or Rock Salt.

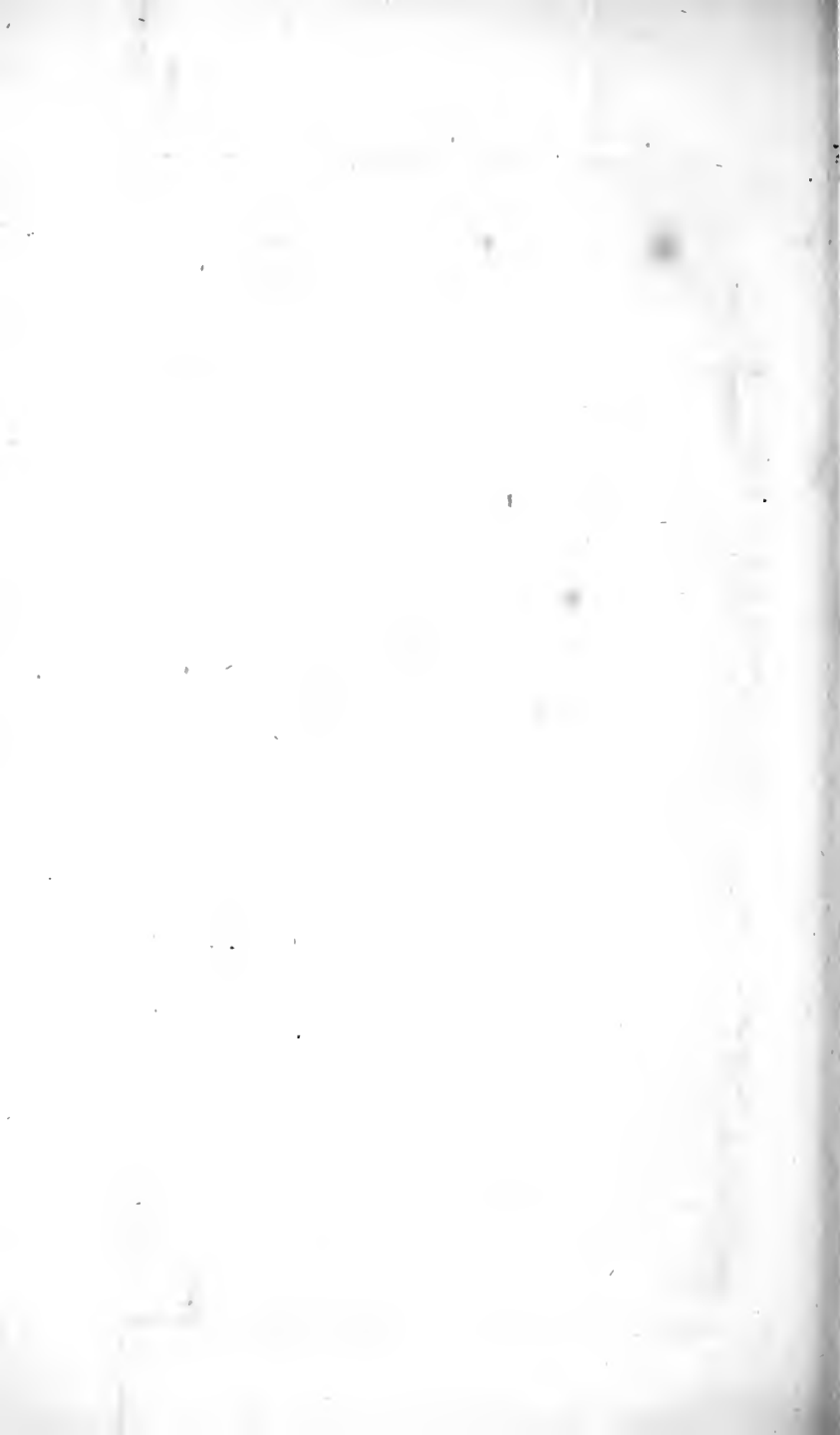


N^o III. Spring Salt.



N^o II. Sea Salt





C H A P. X.

Of VITRIOL in general.

THE most celebrated of our modern Chemists suppose an acid Spirit existing universally in the Air, and pervading the whole terraqueous Globe. This, they tell us, is an uniform Matter, or first Principle, distributed every where throughout the Earth and Atmosphere; though of a Nature so extremely subtile, that it never becomes sensible, unless compounded with other Substances; but, incorporating readily with different kinds of Matter, it composes, they say, therewith all the Variety of Salts, Crystals, Gems, Metals and Minerals; the Colour, Figure, Solidity, and other Properties whereof are owing to the Difference of such Admixture.

This is sometimes called * the *Sal Acidum Fossile*, at other times the *Vague Acid*. Compounded with Earth, and an oily Matter, it is thought to be the Basis of *Sulphur*; of *Alum* with a cretaceous, and of *Vitriol* with a metalline Substance. It is also supposed to be the saline Part, or Principle of all Salts, which *Monf. Homberg* reduces to three Kinds only, *viz.* *Nitre*, *Sea-Salt*, and *Vitriol*.

The

* Vid. *Woodward's Method of Fossils*, p. 37.

The Configurations and Crystals of Vitriol vary according to its different Kinds: and its Difference in Kind is supposed owing to different Admixtures of the same, or different metallic Matter, with that acid Salt (or Spirit) which is the Basis of all kinds of Vitriol. Thus; when Copper is dissolved by and incorporated therewith, the Vitriol produced is blue; when Iron is the Metal, the Vitriol is green; and Lead, Tin, or *Lapis Calaminaris* mixed with Iron is imagined to render the Vitriol white. There is still farther Variety; but Iron appears to be a constant and principal Ingredient in the green and white, as Copper is in the blue.

What occur'd in the Examination of each comes next to be described.

CH A P. XI.

Blue VITRIOL.

ALL Vitriol of this Colour is supposed to receive its Teint from Copper; the best is produced in *Hungary* and the Island of *Cyprus*.

A Drop of the Solution heated a little, and examined as beforementioned, produces Crystals round the Edges, very short

at the Beginning, but increasing gradually as represented *Plate II*, (in the Drawing called *Blue Vitriol*) at the Figures 1, 2, 3, which denote their Difference of Form, and the Progress of their Growth. These crystalline Shoots are solid, transparent, and regular, and reflect the Light very beautifully from their polished Sides and Angles. As the watery Part evaporates, numbers of long slender Bodies resembling Hairs are seen here and there, some lying Side by Side, as it were in little Bundles (*vid. 4.*) and others crossing one another, in such manner as to seem all radiating from a Center, and composing star-like Figures, which see at 5, 5. This Salt proceeds but slowly, and requires some Patience before the Configurations begin to shoot: which they do at last, and that towards the Middle of the Drop most commonly, after a very pretty Fashion, as at 6; and it is to be observed, that here also the principal Lines issue from a Center. Any farther Description of the Drawing seems unnecessary: but it is remarkable, that none of the regular Crystals are found in this Way of Examination, though they are to be obtained in good Plenty by the usual Method of Evaporation, &c.

One of these regular Crystals, of the Size they are commonly found in the Shops, is represented by the two Figures A and B, which

78 *Copper obtained from Iron;*

which shew exactly the different Sides thereof. It consists of ten Planes.

If a Piece of Iron be left for some short time in a Solution of blue Vitriol, its Surface will appear of a Copper Colour, and is really covered with Particles of Copper, either precipitated upon, or attracted by the Iron, to which they firmly adhere, and whose Pores they seem to fill. This may serve to shew, after what Manner some Springs of Water are able to perform what is usually called a Transmutation of Iron into Copper; which indeed is nothing more than a gradual Dissolution of the Iron, whose Place becomes as gradually supplied, and its Figure assumed by the minute Particles of Copper floating in the said Water: so that, although a Mass of Copper may be found, after a Length of Time, instead of a Mass of Iron, there is no Transmutation in the Case. The whole Fact seems only to imply, that the minute Particles of Copper wherewith the Water is stored, being much smaller than the Pores or Interstices between the Particles of Iron, do first of all get into and fill up the said Interstices. We have then a Mass compounded of Iron and Copper; but the Iron Parts thereof becoming gradually corroded and washed away by the Water (the mineral acid Salts it contains rendering it a Menstruum thereto) their Places are immediately occupied by

by Particles of Copper, which the Water brings along with it continually; and a Body of Copper at length is substituted in the room of the Iron that was corroded and washed away. The Petrification of all Bodies that were originally of some other Substance than what they now appear to be, was probably produced after a like Manner; for it seems highly improbable that any Substance whatever can strictly speaking be converted into a Substance of some other Kind, however Appearances may happen to impose upon us.

Dr. *Brown* informs us in his Travels, of two vitriolic Springs, called the old and the new *Ziment*, rising from a Copper Mine in *Hungary*, which in fourteen Days turn Iron left in their Waters into Copper, and that too more pure, ductile, and malleable, than any Copper extracted from the Ore: that he took out with his own Hands from one of these Springs the Figure of an Heart, which had been put thereinto eleven or twelve Days before, and found it as perfect Copper as it had been Iron when put in. Some, he adds, will not allow this to be a Transmutation, but argue, that the Waters being saturated with a Vitriol of Copper, and finding a Body so easy to receive it as Iron is, it insinuateth thereinto so far as to divide and precipitate the Iron, leaving

80. *Copper obtained from Iron,*

leaving its own Substance instead thereof*. And this most certainly is the Fact, though the Doctor seems to doubt it; the Purity of the Copper may be brought in Proof, and is not to be wondered at, for the minute Particles thereof, that floated in the Water, and were deposited in the Pores of the Iron, must necessarily be less blended with foreign Matter than any Copper in its Ore can be.

There are Copper Mines in the County of *Wicklow* in *Ireland*, called the Mines of *Crone Bawm*, or *Corona Alba*, on the North Side of the River *Arklow*, where the Water raised from the Mines, that used to run away in Waste, has lately been converted to great Profit: for by placing Iron Bars on Beams of Timber fixed for that purpose across large Pits or Cisterns, (floored with smooth Flags and lined on the Sides with Stone and Lime) through which the Water runs, the Iron becomes incrufted in a few Days with Particles of Copper: which, being swept off from Time to Time, and falling to the Bottom, are, when a Quantity is collected, taken thence, in a fine brown Powder consisting of Copper and the Rust of Iron; which affords, when
smelted

* Vid. *Brown's Travels* 4^o page 109.

smelted and purified, a rich Copper, 10 £ per Ton more valuable than what is obtained from the Ore of the same Mine.--- This was discovered, by observing, that some Iron Tools of the Workmen, which had fallen accidentally into the Water, were after a while incrufted with Copper.

A Chain of these Pits is already made, each 10 Feet in Length, 4 in Width, and 8 in Depth : and as many more may be sunk as People please, there being a continual Supply of Water to run through them all. They make use of soft Iron, which attracts the Copper Particles best, dissolves, mixes, and precipitates with them in form of a brown Dust. A Ton of Iron in Bars produces one Ton, nineteen Hundred, and two Quarters of brown Dust ; and each Ton of Dust, smelted, affords 16 Hundred Weight of pure Copper. There are at present about 500 Tons of Iron in the Pits. A large Bar of soft Iron will be dissolved in about 12 Months †.

N. B. Whilst the minute and invisible Particles of Copper are floating at Liberty in any Menstruum, they are strongly attracted

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† The above Account is the Substance of a Letter to Sir *Hans Sloane*, which he favoured me with the use of ; and also of another Letter communicated to the *Royal Society* by Lord *Cadogan* : both these Letters were written by the Reverend Mr *William Henry*, who was himself upon the Spot. I have also a Lump of Metal, wherein most of the Iron has been dissolved in the Water, and its place supplied by Particles of Copper.

tracted by Iron ; infomuch that if a Needle or the Point of a Knife be held but for a few Minutes in a Solution of blue Vitriol, or if blue Vitriol be wetted and rubbed upon Iron, it will presently be cas'd over with Copper: and yet when these same Particles are collected into a Mass of Copper, there seems no Attraction between that Mass and a Mass of Iron, nor has the Magnet any sensible Effect on Copper.

Copper affords a blue or a green Tincture, according to the Menstruum wherein it is dissolved ; and therefore is supposed to supply Colour to the *Emerald, Sapphire, Turquoise, Lapis Lazuli, Lapis Armenus,* and most other Stones and Minerals that are either green or blue, as well as to the Subject we are at present treating of. The amazing Variety of *Blues* and *Greens* deducible from this Metal, and the Changes of one into the other, are exceedingly worth the while of every curious Person to satisfy himself about by a Train of easy Experiments ; the Way of making which may be found in *Boyle's Treatise of Colours,* in *Boerhaave's Chemistry,* as translated by Dr. *Shaw,* Vol. II. page 342, &c. and in *Hill's Letter,* printed at the End of his *Theophrastus, on the Effects of different Menstruums on Copper ;* where we are informed, that,

how changeable one into another. 83

that, of the Mineral Acids, Spirit of Sea-Salt, Spirit of Nitre, and Aqua Regia, produce with this Metal different Kinds of *Green* : Oyl of Vitriol, Oyl of Sulphur, and Aqua Fortis, different Degrees of *Blue* : that, amongst the vegetable Acids, distilled Vinegar, Juice of Lemon, and Spirit of Verdigrase (which is a Vinegar absorbed by Copper) afford different *Greens* : that, of the fix'd Alkalies, the Salt of Wormwood, Pot Ashes, and Oyl of Tartar per deliquium, give all a deep and delightful *Blue* ; as do also, among the volatile Alkalies, Spirit of Sal Armoniac, Spirit of Urine, and Spirit of Hartshorn : that, of the neutral Salts, crude Sal Armoniac produces a fine *Blue* ; native Borax a *deep*, and Sea-Salt a *Whitish Green*.

“ A Solution of Copper in any of the
“ beforementioned Acids, so weak as
“ to leave the Menstruum colourless like
“ Water, may in an Instant, by the Af-
“ fusion of a few Drops of Oyl of Tar-
“ tar per deliquium, be converted into a
“ glorious *Blue* ; or by a like Quantity of
“ Spirit of Nitre, into a beautiful *Green* :
“ nay, by this means made *Blue*, may be
“ yet changed into *Green* by a larger Quan-
“ tity of the Acid : and even when thus
“ made *Green*, again converted into its for-
“ mer *Blue*, by a yet larger Quantity of
“ the Alkali.

“ The blue Tinctures of Copper made
“ in the fix'd Alkalies, may also be di-

84 *Tincture from Copper how diffusible.*

“ vested of their Colour, and rendered
“ colourless and pellucid like Water, by
“ Acids, if the Proportions be carefully
“ regarded. The blue Liquor here is made
“ *colourless*, as the colourless Liquor was
“ before made *Blue*; and the pellucid Li-
“ quor thus produced, will exhibit all
“ the Phænomena before described in that
“ originally colourless. To this it may be
“ added, that even the strong blue and
“ green Solutions are easily changed
“ from Blue to Green, and from Green
“ to Blue in the same Manner. ” *

And how far Copper can diffuse its Tincture, (or its Parts become divisible) may be learned from Mr. *Boyle*, who found a single Grain of Copper dissolved in Spirit of Sal Ammoniac, would make 256806 times its own Bulk of clear Water of a blue Colour; would give a manifest Tincture to above 385200, and a faint yet distinguishable one, to more than 530620 times its own Bulk †.

C H A P. XII.

Green VITRIOL, or English Copperas.

OUR Green Vitriol contains a great deal of Iron, but appears not to hold any Copper, which makes its Colour difficult

* *Hill's Theophrastus*, pag. 188, 189.

† *Vid. Boyle Abridged*, Vol. I. pag. 408.

Green Vitriol, or English Copperas. 85
ficult to account for : since all mineral
Substances, whose Colour is blue or green,
have been generally supposed to derive
their Colour from Copper.

When dissolved in Water, it constantly
drops to the Bottom a yellow ferrugine-
ous Sediment ; which being taken away,
the remaining Liquor, after a due Time of
Rest, affords Crystals much clearer and of
a finer Green than the Vitriol was at first.
These being dissolved again throw down
another yellowish Sediment, but in much
less Quantity than before, and when cry-
stalized a-new appear of a still more live-
ly Colour. And by repeating this Opera-
tion, they may be rendered perfectly trans-
parent and of a delightful Green ; tho'
after all some Iron will still be left, which
subjects them to contract a Rust, if exposed
to the open Air.

A Drop of the Solution, moderately heat-
ed, and applyed to the Microscope, be-
gins to crystalize about the Edges, and
proceeds gradually, as the Figures 1, 2, 3.
Plate II. N^o. 2. represent, under the Name
of *Green Vitriol*. After waiting some Time,
the Configurations push out, suddenly and
hastily, towards the Middle, in the Man-
ner represented by Figure 4, which begins
at *a*, and thrusts forwards and sideways
at the same Instant, with wonderful Order
and Regularity, to the other Extremity *b*,

86 *Green Vitriol, or English Copperas.*

where the whole Process is at an End. Its regular Crystals are rarely found in this Examination, but a Couple of them as obtained by dissolving a Lump of our Subject in boiling Water, and leaving it at Rest for a Day or two, are placed at the Side of the Drop. The first of them A, is one out of a great many that were formed on the Side of the Glass wherein the Solution stood, and adhered thereto. These being produced in the clear Part of the Liquor, above the ferrugineous thick Sediment which had been precipitated but was not taken away, were much greener and more transparent than the Vitriol first dissolved. Excepting some Irregularities they were all of the same Shape, with Sides nearly corresponding.

The Figure B represents an Octaëdron, that being the general Shape of many Crystals formed in the yellow thick Sediment at the Bottom, a Fortnight or three Weeks after, the clearer Part of the Liquor having been poured away: and consequently the Difference of Figure between this and the former must be imputed to the much greater Proportion of Iron in this than that.

Our green Vitriol, or English Copperas, is made from the *Pyritæ*, that are found in great abundance on the Shores of *Sussex, Kent, Essex, &c.* These Bodies are
of

Green Vitriol, or English Copperas. 87

of a ponderous and compact Substance, contain Metal and Sulphur, have a rusty ferrugineous Outside, but internally appear, when broken, sometimes of the colour of Brass, Silvery sometimes, and sometimes like Iron; the Matter composing them is disposed in Striæ, or a linear Direction diverging from a central Point to the Circumference, if the Stones have any thing of a circular or cylindric Figure; or lying parallel and perpendicular to the flat Sides, if their Form be flattish. After being long exposed in Heaps to the Air and Rain, the Salts begin to act, vitriolic Efflorescencies push out upon the Surface, they become brittle, fall to pieces, and dissolve into a Liquor. This Liquor when boiled two or three Days in a leaden Cauldron, (Pieces of Iron being thrown in from Time to Time during the boiling and dissolving in the said Liquor) is disposed afterwards in convenient Vessels, where it stands for about a Fortnight to crystalize into Vitriol. A great Work of this Kind is, or was not long ago, carried on at *Deptford*.

C H A P. XIII.

White VITRIOL.

THE White Vitriol from *Goslar* in Germany, as well as that from *Hungary*, contains some little Copper, but the common Sort with us has no other Metal in it besides Iron, unless, as some suppose, there is also a small Quantity of Lead or Tin. The Iron contained in the *Green* and *White*, as well as the Copper in the *Blue*, is not in any constant Proportion, but frequently more or less in different Pieces of the same Parcel, which occasions some Variety in Experiments made therewith.

A Drop of the Solution of white Vitriol begins to shoot at the Edges, by a gentle Degree of Heat, either in small angular Figures, or minute curvilinear Spiculæ, both which are represented in *Plate II*, at 1, 1. The former of these spreading considerably in Breadth, and protruding very slowly forwards, produce those lined Figures shewn at 2 on one Side of the Drop, which are formed by two Planes inclining to one another in an Angle of about 120 Degrees : the latter, *viz.* the *Spiculæ*, spreading likewise and flattening at the Ends, shew themselves nearly as represented by 2 on the contrary Side,
Some

Some of them however shoot farther into the Drop, in the Manner shewn at 3, 4, and 5 : and many so shot out have other smaller ones protruded from their Sides, parallel to one another, and forming an Angle with their main Stem of about 60 Degrees, as at *a, a* : when the Process is nearly over, many extremely minute *Spiculæ* arise in the Interspaces ; some uniting in, or rather shooting from Centers, and making a very pretty † radiated Appearance, like what was before observed in the blue Vitriol ; whilst others of the same *Spiculæ* are seen scattered and dispersed about the Drop in all Directions, as at 8. These *Spiculæ* may be termed a Characteristic of the Vitriols, being usually found in all of them, when examined by the Microscope with Care ; but as sometimes the *Green* is seen without them, I have taken no Notice of them there.

The Figure shewn at 6 is seldom to be met with, but when the Fluid Part of the Drop is suffered to evaporate without any Heat ; and it seems nearly to approach the regular Crystals, which are next to be described.

As a Solution of our present Subject does not so easily crystalize by the common
Methods,

† It is observable, that many of the *Pyritæ* exhibit Lines diverging from a Center, exactly in the same manner.

Methods, after trying several times to make it do so without Success, I have contented myself with examining the * *Gilla* or *Sal Vitrioli* made by the Chemists: two Figures whereof A B as magnified above a thousand times in the Area, are given at the Side of the Drop. They appear to be quadrilateral Columns, the Inclination of whose Sides is oblique, having generally a quadrilateral Pyramid at each End, formed of triangular Sides corresponding to those of the Column, as at A ; but sometimes these triangular Planes intersect, in such a manner that the Angle at the Apex is comprehended under only three of them, as at B.

Vitriol in considerable abundance is found in Substance and of different Colours, blue, green, white, and red, in several Parts of *Hungary*, *Germany*, and other Countries : but very little, if any, native Vitriol is ever found in Masses or Lumps in *England* ; all produced here being obtained by Art from the *Pyritæ*, and of the white the greatest Part comes to us from abroad. The Appearance of such White Vitriol is extremely like Loaf Sugar, it has a sweetish disagreeable stiptic Taste, and when
dissolved.

* These Salts or Crystals are obtained by the Help of Spirit of Vitriol, or, as *Lemery* directs, by dissolving White Vitriol in the Phlegm of Vitriol.

dissolved in Water, throws to the Bottom a ferrugineous Sediment like the Green.

It would be endless to enumerate all the Uses of Vitriol. Sir *Kenelme Digby's* sympathetic Powder, so famous in its Day for the Cure of Wounds, was nothing else but Vitriol exposed to the Summer's Sun for several Days and powdered. But amongst all the rest, its being an Ingredient absolutely necessary for the making of Ink is not the least to be regarded. Any Vitriol that contains Iron will serve to this Purpose, of what Colour soever it be: the Green however is commonly preferred, as holding a greater Quantity of that Metal: but the White sometimes is not less stocked with it, and then will do full as well. Galls unripe, or gathered when they are of a blueish Colour, before they come to their full Growth, being beaten to Powder, and infused in Water, give the Water a stiptic Taste, without altering its Colour much; but a proportionable Quantity of powdered Vitriol, or a Solution of Vitriol being mixed therewith, turns it instantly as black as Ink, and wants only a little Gum to make it Ink indeed. A Decoction of the dried Leaves of red Roses, of Sage, Oak Leaves, or the Rinds of Pomegranates, produces the same Appearance therewith. It also in like manner blackens an Infusion of Green Tea;
and

and therefore a few Tea Leaves put to steep for some Minutes in any Mineral Water made hot, will readily discover if it contains Vitriol, by such its Change of Colour : the Proportion of the Vitriol may likewise be guessed at by the Deepness or Paleness of the Tincture.

On writing with a Solution of Green Vitriol, nothing is seen upon the Paper when dry : but by rubbing it over with a Decoction of Galls, what was written becomes black and legible. Spirit of Vitriol wiped gently upon this, makes it vanish again immediately : Oyl of Tartar *per deliquium* restores the Letters once more, though not black but yellowish †.

A strong Decoction of red Roses mixed with a Solution of Vitriol produces a black Ink, which on dropping Spirit of Nitre into it becomes instantly red, and is farther convertible into a greyish Liquor, by adding a little of the volatile Spirit of Sal Armoniac.

Good Writing Ink being not always or every where to be procured, it will not perhaps be unacceptable to give here an easy Way of making it, which I can recommend from many Years Experience.

To one Quart of Rain Water, or soft River Water, put four Ounces of blue
Galls

† Vid. *Lemery's Chemistry*. chap. 18.

Directions for making Ink. 93

Galls bruised, two Ounces of green Vitriol or Copperas, and two Ounces of Gum Arabic grossly powdered. Let the Mixture be well shaken or stir'd about now and then, and in twenty-four Hours it will be fit for Use. It is most conveniently made in a wide-mouthed Bottle that will hold near double the Quantity, where it may sometimes be shaken together briskly ; but be sure you let it settle again before you pour any off. When you have used all that can be got off clear, a little more than half the Quantity of the same Ingredients will make you another Quart.

What is written with this Ink looks pale at first, but after a few Hours becomes of a fine black, and I believe will never change.

C H A P. XIV.

Distilled VERDIGREASE.

VERDIGREASE is a blueish green Efflorescence * or Rust, produced on Plates of Copper, by corroding the Surface thereof with that penetrating acid Spirit which the Husks of Grapes abound with after they have been press'd and laid together to ferment. This Rust being

* Vid. *Levery's Chemistry* chap. vi. *Boerhaave's Chemistry*, by *Shaw*, Vol II. pag. 137.

being digested with distilled Vinegar in a considerable Degree of Heat, and dissolving partly therein, affords a Liquor of a most beautiful green Colour, which after Evaporation, being set in a cold Place, produces transparent and elegant green Crystals, that are called usually by the Name of *Distilled Verdigrease*, but are really a Vitriol loaded with the purest Particles of the Copper.

If these Crystals are dissolved in warm Water, and a Drop of it be apply'd to the Microscope immediately, it usually produces abundance of the regular Figures 1, 2, 3, 4, 5, 6, 7, (exhibited at the Side of the fourth Drawing, *Plate II.*) without forming any considerable Configuration: but if the Solution is suffered to stand quiet for a few Hours, and a Drop of it be heated over the Fire on a Slip of Glass, till it begins to concrete about the Sides, and then examin'd, sharp-pointed solid Figures (bisected by a Line through the Middle, from which they are cut away towards the Edges) will be seen, shooting forwards, as represented 1, 1, 1: which Figures are oftentimes striated very prettily from the middle Line to the Edges, obliquely, as 2, 2, may serve to shew. They both arise frequently in Clusters, and shooting from a Center, as at 3, 3.

The forementioned Figures are a long while growing; and whilst they are doing
so,

so, several regular Crystals appear forming in different Parts of the Drop, of the most lovely Emerald Colour, and reflecting the Light from their Sides and Angles, which are as exactly disposed and finely polished as if they had been cut by the most skilful Jeweller. These Crystals are shewn in the Drop at 4, 4, but much better, because magnified a great deal more, at the Side of it, by the Figures 1, 2, 3, 4, 5, 6, 7.

No Configurations form themselves in the Middle of the Drop till the Fluid be nearly evaporated, but when they begin to form they proceed somewhat hastily, and therefore must be attended closely. Their common Figure resembles two long *ff*, crossing each other in an Angle of about sixty Degrees, and shooting Branches every Way: each of which again protrudes other Branches from one, and sometimes both its Sides, making together an Appearance like four Leaves of Fern conjoynd by their Stalks, as at 5, 5. Separate Clusters of the same sharp-pointed Figures, as those at the Edges of the Drop, are formed also frequently in the Middle of it, as 6. Sometimes also they put on another Form like the Leaves of Dandelion, as at 7. Very beautiful Figures are likewise produced by a Kind of Combination of sharp Points and Branches, in the Manner represented 8 8.

All the beforementioned appear of a most lovely green Colour, but deeper or paler according to the Time of their Production; the first produced being constantly the deepest. Towards the End of the Process some circular Figures are formed, extremely thin, and so slightly ting'd with green that they are almost colourless, but with Lines radiating from a Center to the Circumference, like the star-like Figures of *Alum* hereafter to be described. These are shewn 9, 9. When all seems in a manner over, Bundles of Hair-like Bodies appear frequently, scattered here and there throughout the Drop, in the same Manner as described in the blue and white Vitriols.

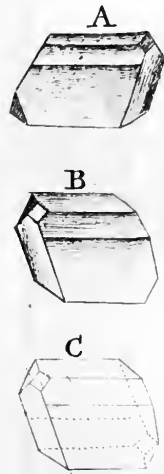
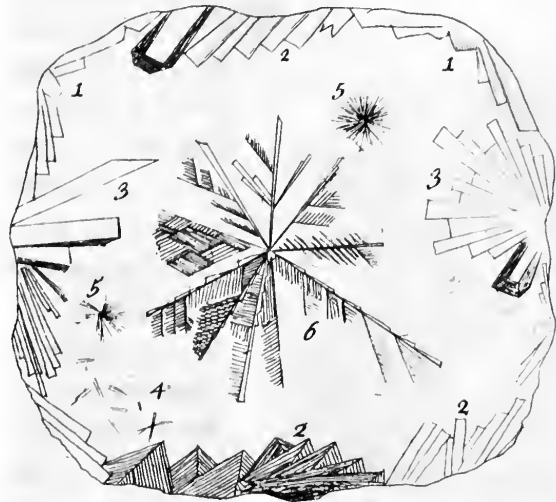
C H A P. XV.

ALUM.

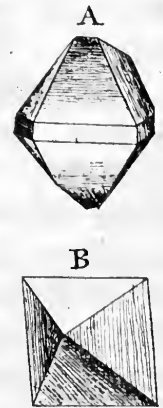
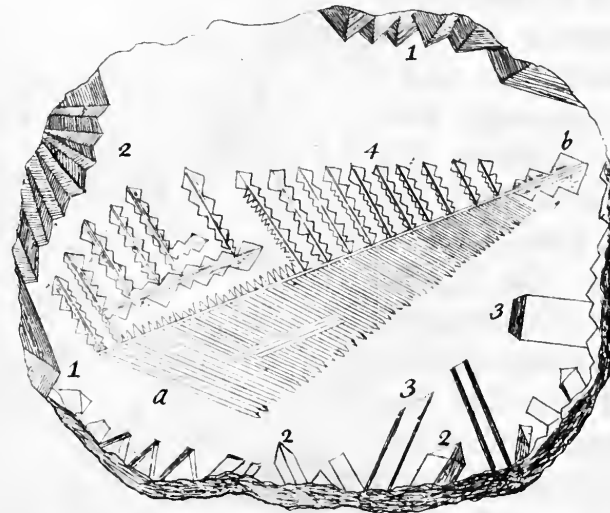
THE Configurations of this Salt abound with Beauty and Variety, and prove more or less perfect according to the Strength of the Solution, and the Degree of Heat employed in making the Experiment, to judge of which a little Experience will be found needful.

The Solution, however sated with *Alum*, will not be found over-strong after standing
some

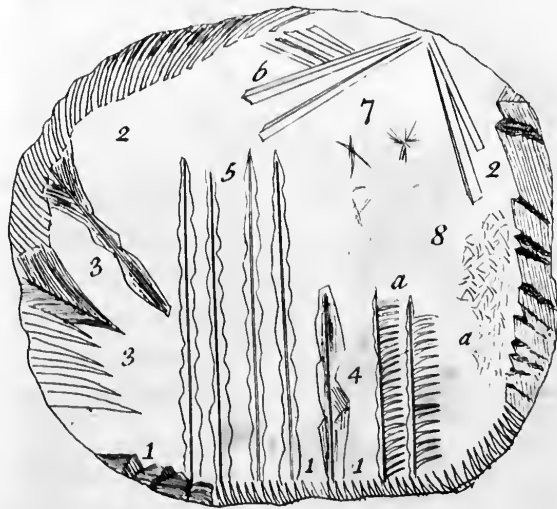
Blew Vitriol.



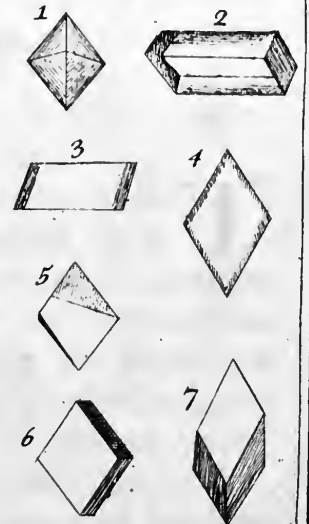
Green Vitriol.



White Vitriol.



Verdigrease distilled.



Date	Description
1861	Jan 1
1861	Feb 1
1861	Mar 1
1861	Apr 1
1861	May 1
1861	Jun 1
1861	Jul 1
1861	Aug 1
1861	Sep 1
1861	Oct 1
1861	Nov 1
1861	Dec 1
1862	Jan 1
1862	Feb 1
1862	Mar 1
1862	Apr 1
1862	May 1
1862	Jun 1
1862	Jul 1
1862	Aug 1
1862	Sep 1
1862	Oct 1
1862	Nov 1
1862	Dec 1
1863	Jan 1
1863	Feb 1

some Days, for in that Time it will have precipitated many Crystals to the Bottom, whereby the Liquor is sometimes left too weak for our Purpose ; but then by holding the Phial over or near a Fire, the Crystals will again dissolve, and be taken up a-new into the Fluid. 'Tis not however adviseable to make use of it as soon as this is done, unless we want to produce nothing else but Crystals: for if, after this, it be employed before it has had a little Time to cool and settle, it is very apt to form into Crystals only: But when it has stood about half an Hour, a Drop placed on a Slip of Glass and heated properly, exhibits commonly at the beginning a dark Cloud, which appears in Motion somewhere near the Edge, and runs pretty swiftly both to the Left and Right, until it is either stopped by the Intervention of some regular Crystals, or else proceeds onwards both Ways at once, and nearly of the same Height, till having surrounded the whole Drop the two Ends rush together and joyn; the Progress towards which is attempted to be shewn, *Plate III. N° I. a a.*

This cloudy Part of the Drop that seems violently agitated whilst it is running round, appears on a strict Examination to consist of Salts, shot into long and very slender Lines, much finer than the smallest Hair, which cross one another at right Angles, and form

as they go along, from their internal Edges, Rows of solid Crystals composed of many oblique plain Sides *b b*, and which have all a Tendency towards the Figures of the regular Crystals to be described presently.

But it happens frequently, that in some Parts of the Drop many minute and circular Figures are seen, rising at some little Distances from the Edge, whilst the above mentioned Operations are performing in other Places thereof; which minute Figures enlarging themselves continually, appear at last of a star-like Form, or with Lines radiating and diverging from a Center, in the Manner represented *c c*.

After the Business is over about the Edges, a good deal of Patience will be requisite to wait for the Configurations in the Middle of the Drop, which seldom begin till the Fluid seems almost wholly evaporated; when on a sudden many strait Lines appear pushing forwards, whose Sides or Edges are jagged, and from which other similar strait and jagged Lines shoot out at right Angles with the first; these again have other small ones of the same Kind shooting likewise from themselves, and compose all together a most beautiful and elegant Configuration, the Order of which is attempted to be shewn at *D*.

Each

Each of these Lines increasing in Breadth towards its End, appears somewhat club-headed, as *e e e*.

Sometimes instead of sending Branches from their Sides, many of these Lines rise parallel to each other, resembling a kind of Palisadoe, and having numberless minute tranverse Lines running between them, as at F.

But the most wonderful Part of all, tho' not produceable without an exact Degree of Heat and right Management, is the dark Ground-work shewn at G, which consists of an almost Infinity of parallel Lines, having others crossing them at right Angles, and producing a Variety scarce conceivable from Lines disposed in no other Manner: the Direction of the Lines (which are exquisitely strait and delicate) being so frequently and differently counter-changed, that one would think it the Result of long Study and Contrivance.

During the Time this Ground-work is forming, certain lucid Points present themselves to view (on one Side thereof most commonly) which Points grow larger continually, with Radiations from a Center, and become star-like Figures, in the Manner of those beforementioned. Several of them likewise shoot out long Tails, which give them the Appearance of Comets: and at the End of all, a dark Lineation in va-

rious Directions, darts frequently through, and occupies all or most of the Spaces between them, making thereby no ill Representation, when viewed by Candle-Light, of a Night-Sky illuminated with shining Stars, and tailed Comets, and rendering the whole Scene extremely whimsical and pretty.

Nor do these Configurations break away, or dissolve, soon after their being formed, as many others do; but may be preserved on the Glass in good Perfection for Weeks or Months, if Care be taken neither to exclude the Air wholly from them, nor put them in a moist Place: for in either Case they will be soon destroyed.

Being desirous to preserve some exceeding fine Star and Comet-like Figures, I fastened another Glass of its own Size upon the Slip where they were formed; having first placed thin Pieces of Cork between, to prevent the Glasses from touching, and after all stopped the Ends and Sides with Sealing Wax, thereby to keep out the Air, which I imagined would spoil them: but contrary to my Expectation, in two Days the Figures were all obliterated; whereas another Configuration, covered with a Slip of Glass to preserve it from being touched, but whose Sides were open to the Air, continued in great Perfection at least two Years, and then too was spoiled by Accident.

The

The same Thing likewise happens to *Saccharum Saturni*, *Ens Veneris*, *Salt of Amber*, and some other saline Substances, whose elegant Configurations may be long preserved between Slips of Glass kept asunder as above directed, provided the Air be not pent up with them, and that the Place you put them in be dry. I have at this Time several Configurations formed some Years ago; and it will save much Trouble, and be most agreeable to People not overstock'd with Patience, to have always as many kinds as one can thus ready, to shew such Friends whose Curiosity may not be sufficient to make them attend to the whole Process.

A great deal of Exactness and Nicety is requisite as to the Degree of Heat, to make one and the same Drop produce all the Configurations presented in the Plate; tho' you will certainly meet with several of them in every Drop you try, unless the Heat be too long continued, in which Case the Fluid becomes hardened by the Fire into a kind of transparent Gluten, which never shoots at all, is not easily dissolveable, or to be got off the Glass without some Pains. On the other hand, if the Heat be violent, though not long, it shoots too fast, with much Irregularity and Confusion.

The regular Crystals are often formed in the same Drop with the other Configurations, as at *f*. But if not, they may easily be produced, either by using a Solution made with hot Water, before it cools; or by placing a Drop of a well-saturated Solution when cold, on a Slip of Glass, and suffering the Fluid to evaporate without any Heat at all. Crystals will also be formed by Precipitation after the Solution has stood some Time.

After numberless Observations to determine the Crystals of *Alum*, I find amongst them the following Variety.

Some are exactly regular Octaëdra, composed of eight equilateral Triangles, as the Figure A.

But as they lye most frequently on one of their triangular Bases, they appear in the Manner shewn at B.

Others appear like the above with their solid Angles cut off, forming thereby a Figure of fourteen Sides, eight of which are Hexagons, and the other six Squares, as C.

The Figure D frequently presents itself, and seems also composed of fourteen Planes (*viz.* 12 quadrilateral, and two hexagonal) the Planes underneath being supposed to correspond in Number and Figure with those that appear above.

E repre-

E represents an eight-sided Figure, consisting of two triangular, two hexagonal, and four quadrilateral Planes, two whereof slope downwards from the upper hexangular Plane, and the other two upwards from the under one.

The Figure at F is compounded of eight Planes, the undermost whereof is a large equilateral Triangle, from each Side of which a sloping quadrilateral Plane proceeds. These Planes are Trapezoids, each of them having a Side in common with that of the Triangle, another shorter one parallel thereto, and two others sloping one towards the other, and towards the Side of the Triangle, in a Direction of about twenty Degrees.

The Plane which lyes parallel to the Triangle (which Plane in the present Figure is next the Eye) is hexagonal, three of its Sides being made up of the shorter parallel Sides of the Trapezia: the other three (which are less than these, being cut down perpendicularly, so as to meet the Angles of the large Triangle) form three other smaller Triangles, each whereof has one Side in common with the Hexagon, and the other two with the neighbouring Trapezoids.

Our *Alum* is obtained from a blueish mineral Substance resembling Slate, which after being calcined and steeped in Water

for a due Time, that Water when boiled sufficiently in Pans of Lead (the Lees of Sea-Weed Ashes called Kelp, and a Quantity of Urine being mixt therewith) produces Shoots of *Alum*, after standing a few Days. But as such Shoots are seldom clean enough at first for Sale, they commonly are washed with or dissolved again in Water, freed from their Impurities, and set to concrete a-new.

Vast Quantities are made in *Yorkshire* and *Lancashire*, most of the Hills between *Scarborough* and the River *Tees*, as well as those near *Preston*, abounding with this Mineral; the Salts of which being dissolved and put in Action by the Moisture of the Air, if thereto exposed, without being calcin'd, the Mineral falls in Pieces, and yields a Liquor whereof *Copperas* or green *Vitriol* may be made. †

Alum may also be procured from certain Earths by pretty much the same Means. An Earth of this Kind now lies before me, which was brought from *Africa*, where a considerable Tract of Land is said to be of the same

† At *Altsettle* in *Bohemia* are Mines of black *Schistus*, whence they make great Quantities of *Alum* and *Vitriol*; and from a *Gleba Pyritosa* found in the same Mines, they obtain much *Sulphur*. I am obliged to Dr. *James Vounsey* for this Information; and for Specimens of both the Substances, which he collected upon the Spot and sent me.

same Sort. * It tastes exactly like *Alum*, and in the *South Sea* Year 1720, a Quantity was imported in Hopes of making it turn to good Account: but the Mischiefs suffered from other Projects at that Time, discouraged People from embarking in this, and we have heard no more of it since; nor indeed as *Alum* can be made so cheap from Materials found at Home, does it seem worth while to send so far on the same Account.

Alum seems so nearly a-kin to Vitriol, that the Addition of Copper or Iron is only wanting to make it the same Thing; as may be proved by a Distillation of it into an acid Spirit with either of them, whereby it becomes good Vitriol. On the other hand, Vitriol when freed from its metallic Particles, becomes aluminous, and yields on Distillation a Spirit undistinguishable by the nicest Scrutiny from that of *Alum*.†

C H A P.

* I have also an aluminous Earth, brought from *Maryland*, and given me by Mr. *Brook*.

† Vid. *Phil. Transf.* N^o 104. p. 67.

C H A P. XVI.

BORAX.

BORAX is a saline Substance, very difficult of Solution unless in boiling Water, and even then requiring, according to *Boerhaave*, twenty Times its own Weight.

When a Drop is given to be examined by the Microscope, if it be held too long over the Fire no Crystals will shoot, but it will harden upon the Slip into a transparent Matter much resembling Glass. The best Way is to give it a brisk Heat for about one Second of Time, and then applying it, the Crystals will quickly be seen forming about its Edges, as in *Plate III. N^o II.* where their Beginning and Progress are so represented as to need no farther Description.

In the middle Parts of the Drop no Crystals at all arise, but there are several transparent circular Figures, that from mere Specks grow gradually bigger, till they resemble small Drops of Oyl floating upon the Surface of Water : these also are shewn in the Drawing.

This Salt is said to be found in *India*, *Persia*, and *Tartary*, and to be brought from those Countries rough and foul,
in

in Lumps or Crystals, of a yellowish and sometimes of a dirty green Colour: but we really know little thereof with Certainty. The *Venetians* made great Profit heretofore by purifying it for Sale*, but that Trade at present is chiefly carried on by the *Dutch*; though I am told the Secret is become known, and has lately been practised with good Success in *England*. It serves the same Purposes of fusing and soldering Gold and other Metals, as the *Chrysocolla* of the Ancients did, for which Reason it is frequently called by the same Name, though theirs was quite another kind of Substance, the Knowledge whereof is probably lost to us. Its glassy Quality renders it useful in dying, to give a Glossiness to Silks; and Dr. *Shaw* proves (in the twentieth of his *Chemical Lectures*, Experiment 3d.) that by means of this Salt a Kind of Glass may be made of an extraordinary Degree of Hardness; and imagines the Arts of Enamelling, and of imitating precious Stones, may be greatly improved thereby†.

When

*Vid. *Shaw's Translation of Boerhaave's Chemistry*, Vol I. p. 110, in the Notes.

† Rough *Borax* is called *Tincal*, or *Tincar*. *Geoffroy* says, a salt muddy greenish Water found in some Copper Mines, evaporated to a certain Degree, then kept for several Months in Pits, whose Sides and Bottoms are plaistered with the Mud of the same Mines mixt with Animal Fat, the Pits being also covered with the same Plaister, produces the Lumps or Crystals of *unrefined Borax*.

When refined and pure it is bought in large crystalline Shoots clean and white, about the Clearness and Hardness of Alum, wherewith it is sometimes adulterated: to the Taste it is almost insipid, but somewhat smooth and oily; and the more so the less it has been purified, for in its foul State 'tis considerably fat and greasy.

A regular Crystal of such purified Borax as taken by the Microscope, is shewn on the Side of the Drop at A.

Some Years ago my worthy Friend Mr. *Peter Colinson*, F. R. S. favoured me with a Substance said to be brought from *Persia*, and called *Native Borax*: 'tis in small irregular flattish Pieces of a greyish white Colour, wherein, if nicely examined, abundance of shining Particles may be discerned: it is light and porous, of a very brittle Consistence, somewhat urinous, and more pungent in Taste than the Kind before described. A Solution of this did not shoot at all into Crystals, but in many Examinations filled the whole Drop with figur'd Bodies like that at B; which from being barely visible, enlarged pretty fast, to a Size (when viewed by the fourth Magnifier) as big in Appearance as the Figure here exhibited.

These quickly fall to Pieces, and become dissolved by the Air,

C H A P.

C H A P. XVII.

Salt AMMONIAC, or ARMONIAC.

WHAT the Ancients called by this Name, is supposed to have been a Salt generated in the Earth or Sands, from the Urine and Dung of Camels, (made use of by the Multitudes of Pilgrims that resorted to the Temple of *Jupiter Ammon*) which, being sublimed by the Sun, produced this Kind of Salt; and the Difuse of that Custom for many Ages, is imagined to be the Reason why none of it is now found. What we have at present is undoubtedly factitious, being made of Urine, Sea-Salt, and Soot. It is supposed to come from *Egypt* or *Syria*, in round Cakes near three Inches thick, and about half a Foot in Diameter: in Colour it is greyish on one Side, and appearing, for the most part, black, or rather sooty on the other. When broke, the Inside (if good) is white, transparent and crystalline, and in Appearance much like Camphire. We are told, that in those Countries they collect a Soot from the burning of Camel's Dung, which they sprinkle with a Solution of Salt made in Urine of the same Animal, and then sublime in Glass Vessels, till a Cake is thrown up to the Top of each, correspondent to the Shape of the Glass, which they must break

break in order to get it out.---All this may perhaps be true, but I am apt to think it is made much nearer home, and by more easy means.

Some of this Salt dissolved in Water, and a Drop thereof placed on a Slip of Glass, to be examined by the Microscope, will be found to shoot with a small Degree of Heat; which must be very carefully observed, for if more Heat than just enough be given to it, the Configurations will run into one another, and make the Whole appear in great Confusion.

It begins with shooting from the Edges great Numbers of sharp, but thick and broad *Spiculæ*, from whose Sides are protruded as they rise many others of the same Shape, but very short, parallel to each other, but perpendicular to their main Stem, as at 1. *Plate III. N^o. III.* These *Spiculæ* arrange themselves in all Directions, but for the most part obliquely to the Plane from whence they rise, and many are frequently seen parallel to one another: which Particulars the Figure endeavours to express at 1. 1.---As they continue to push forwards (which they do without increasing much in Breadth) some shoot from them the small *Spiculæ* only, as at 2. Others, after they are nearly come to their full Growth, divide into two Branches in a Manner different from all other Kinds
of

of Salt I have ever seen, by the Splitting of the Stem, longitudinally, from the Top almost to the Edges of the Drop, but without any Shootings from the Inside, as is represented at 3.---Other Branches, besides the small *Spiculae* mentioned above, protrude longer ones of the same Form, from whence others also proceed: which others shoot also smaller ones from them, and so on to many Gradations, as at 4.

Before the Middle of the Drop begins to shoot, several exceedingly minute Bodies may be discerned at the Bottom of the Fluid. These rise to the Top in a little while, and as soon as their Form can be distinguished, whilst yet extremely small, they plainly wear the same Shape exactly, which they afterwards appear in when grown much larger, as is shewn at 5.--- Their Growth is very quick, and pretty equal for a Time, but at length some one Branch gets as it were the Mastery, and shooting farther than the rest, forms the Figure 6. The other Branches inlarge but little afterwards, all the Attraction seeming biased to this alone, from which more Branches being protruded, and they again protruding others, the whole appears like Figure 8.

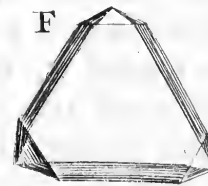
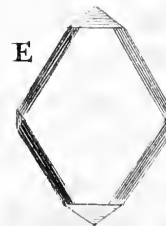
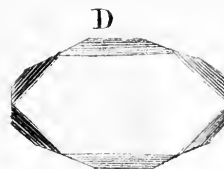
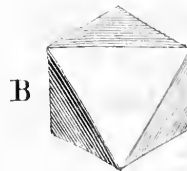
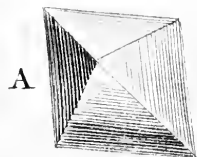
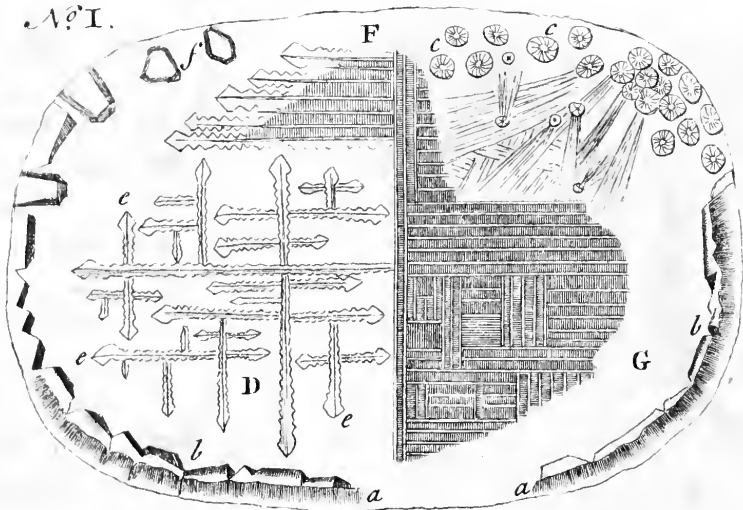
'Tis not uncommon to see in the Middle of the Drop some different Configurations, where instead of the strait Stems described above,

above, there is formed a Kind of *Zigzag*, with *Spiculæ* like those in the other Figures, as at 7.

To obtain the Crystals of this Salt, 'tis necessary to place a Drop of a fresh Solution (made in warm Water) before the Microscope, without giving it any other Heat than the Warmth of the Water. The regular Crystals will then appear as represented at the Side of the Drop A, B, C. The last of which Figures C is produced from the second B, by new Formations at each Corner of the cross Branches, when the whole Process is nearly ended: but these Crystals are rarely seen unless the Solution be examined as soon as made.

Salt Ammoniac is particularly remarkable for rendering Water wherein it is dissolved colder than any other Salt can do, and even equal in Degree to Water that is near freezing. Monsieur *Geoffroy* placed a common Thermometer of eighteen Inches long in a Phial wherein he had put a Pint of Water, and let it remain therein a sufficient Time to adjust itself to the Temperature of the Water: he then put into the Water four Ounces of *Salt Ammoniac*, and in less than a Quarter of an Hour the Liquor in the Thermometer descended two Inches and nine Lines. He then tryed the same Experiment with *Salt-Petre* instead of *Salt Ammoniac*, using the like Precautions, and the
Liquor

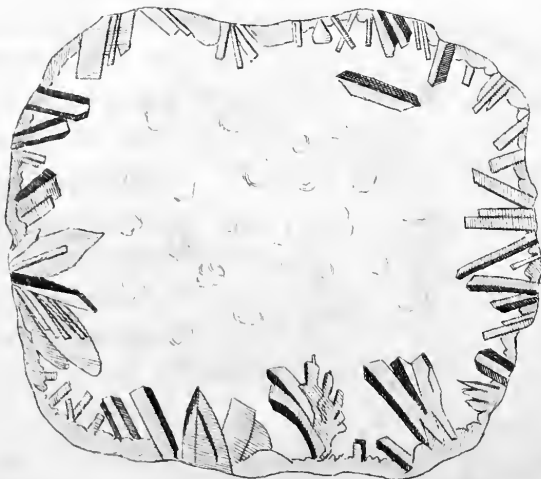
N^oI.



N^oII.

Borax.

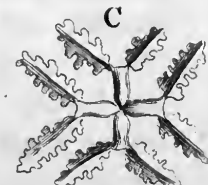
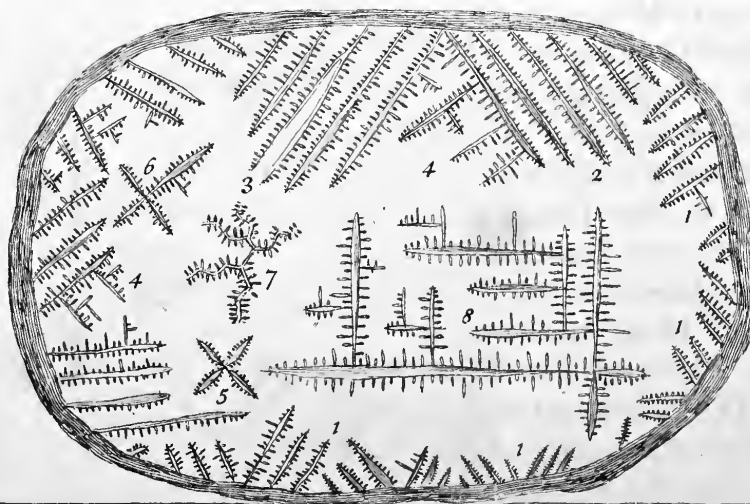
Chrifitals.



N^oIII.

Salt Armoniac.

Chrifitals.



Date	Description	Amount
1861	Jan 1	100.00
1861	Feb 1	200.00
1861	Mar 1	300.00
1861	Apr 1	400.00
1861	May 1	500.00
1861	Jun 1	600.00
1861	Jul 1	700.00
1861	Aug 1	800.00
1861	Sep 1	900.00
1861	Oct 1	1000.00
1861	Nov 1	1100.00
1861	Dec 1	1200.00
1862	Jan 1	1300.00
1862	Feb 1	1400.00
1862	Mar 1	1500.00
1862	Apr 1	1600.00
1862	May 1	1700.00
1862	Jun 1	1800.00
1862	Jul 1	1900.00
1862	Aug 1	2000.00
1862	Sep 1	2100.00
1862	Oct 1	2200.00
1862	Nov 1	2300.00
1862	Dec 1	2400.00

Liquor descended one Inch and three Lines. *Vitriol* made it descend not quite an Inch, and *Sea-salt* but two Lines.

Monfieur *Homburg* orders a Pound of *Salt Ammoniac* and a Pound of corrosive Sublimate to be feparately reduced to Powder; then, after mixing them well together, he directs them to be put into a Glafs Bottle, and a Pint and a half of diftilled Vinegar to be poured thereon. This done, and the Composition being shaken together briskly, it will become fo cold, that a Man can but ill endure the Veffel in his Hands even in the Summer-time. He fays, that once, as he was making this Experiment, the Mixture happened to freeze; and Monfieur *Geoffroy* tells us the like Accident befel him once, on difolving a large Quantity of *Salt Ammoniac* in Water, fome Drops on the Outside of the Glafs freezing: the wet Straw whereon it stood, was likewise faftened thereto by Ice. But though he try'd many times he could never produce Ice again.

It is not my Purpose to enumerate the feveral Ufes of this Salt; I fhall therefore conclude with obferving, that it is extremely pungent, converts *Aqua Fortis* into an *Aqua Regia*, caufes Tin to adhere to Iron, and difsolved in common Water, is, I am informed, a Secret for the taking away of Warts.

C H A P. XVIII.

Salt of LEAD.

THIS Salt which from the Sweetness of its Taste, is usually called *Sugar of Lead*, is prepared from Ceruse or White Lead digested with distilled Vinegar in a Sand Heat to a Dissolution : then evaporated till a Film arises, and set in a cold Place to crystalize. It is therefore Lead reduced into the Form of a Salt by the Acid of Vinegar, for Ceruse is itself nothing else but the Rust of Lead corroded by Vinegar.

A little of this Salt dissolved in hot Water, which it immediately renders milky, after standing a Quarter of an Hour to subside, is in a fit Condition for an Examination by the Microscope. A Drop of it then applied on a Slip of Glass, and held over the Fire to put the Particles in Action, will be seen forming round the Edge a pretty even and regular Border, of a clear and transparent Film or glewy Substance; (*See Plate IV. N° I. a a a a.*) which, if too sudden and violent Heat be given, runs over the whole Area of the Drop, and hardens, and so fixes on the Glass, as not be got off without much Difficulty. But if a moderate Warmth be made use of (which likewise must not be too long continued) this Border

pro-

proceeds a little Way only into the Drop; with a Kind of radiated Figure composed of a Number of fine Lines, or rather Bundles of Lines, beginning from Centers in the interior Edge of the Border, and spreading out at nearly equal Distances from each other every Way towards the Exterior, *b b b b*. However it is observable that the Distances between the Lines are filled up with the glewy Matter, nor do the Lines themselves seem detached therefrom, but are formed together with it. From these same Centers are produced afterwards a Radiation also inwards towards the Middle of the Drop, composed of Parallelograms of different Lengths and Breadths; from one and sometimes both the Angles whereof there are frequently seen Shootings so exceedingly slender, that they are perhaps the best Representation possible of a mathematical Line, which appear like a Prolongation of one or both the Sides. The Extremities of these Parallelograms are most commonly cut off at right Angles, but they are sometimes also seen oblique. The whole of this Description is shewn *c c c c*.

Centers with the like Radii issuing from them, and some of the glutinous Matter for their Root, are sometimes formed in the Drop, intirely detached from the Edges, and in these it is very frequent to find a Sort of secondaryRadii proceeding from someone

of the primary ones, and others from them again to a great Number of Gradations, forming thereby a very pretty Figure, the Representation of which is given at D.

Give me Leave now to observe, that radiated Figures of Spar much resembling these, and which probably owe their Form to the same Principles, are sometimes found in Lead-Mines, of which I have at this Time a Specimen before me.

Notwithstanding it may seem wandering from my Purpose, I should think myself greatly wanting in my Duty towards Mankind, if I closed this Chapter without warning them of the Mischiefs that may arise from taking this or any other Preparation of Lead internally, as the poisonous Qualities of that Metal are not to be subdued or cured, and those who have much to do with it seldom fail sadly to experience its bad Effects. I am sensible this Salt has frequently been prescribed in Quincies, Inflammations, and other Disorders where great Cooling has been judged necessary: But Dr. *Boerhaave* declares he never knew it given with Success, nor durst himself ever prescribe it internally, from his Knowledge that there is scarce a more deceitful and destructive Poison than this, which returns to Ceruse as soon as the Acid is absorbed therefrom by any Thing it may meet with: and that it proves afterwards a most dangerous
and

and incurable Poison. Ceruse, the fine white Powder of Lead, drawn with the Breath into the Lungs, occasions a most violent and mortal Asthma; swallowed with the Spittle it produces inveterate Distempers in the Viscera, intolerable Faintings, Pains, Obstructions, and at last Death itself: which terrible Effects are seen daily amongst those who work in Lead, but principally amongst the White-Lead Makers.*

The Fumes of melted Lead are a Secret with some for the fixing of Quicksilver, and rendering it so solid that it may be cast into Moulds, and Images may be formed of it, which when cold, are not only hard, but somewhat brittle, like *Regulus* of *Antimony* †.

C H A P. XIX.

Salt of TIN.

SALT of *Tin* is obtained in the same Manner as *Salt of Lead*, by digesting the calcined Metal in distilled Vinegar, and setting it, when poured off, in a cool Place, for the Salts to shoot: which they will do in the Form of Cubes.

I 3

This

* *Boerhaave's Chemistry* by *Shaw*, Vol. II. p. 286.† *Vid. Sherley on the Origin of Bodies*, pag. 18.

This cubic Salt being dissolved in Water, and a Drop of the Solution placed under the Microscope, in the Manner before directed, produces such an Appearance at the Edges of the Drop as *a a* represent, consisting of Octaëdra, partly transparent, standing on long Necks, at small Distances from each other, with angular Shoots between them. At the same time solid and regular opaque Cubes will be seen forming themselves in other Parts of the Drop, *vid. b b. Plate IV.*

These may be discerned when their magnified Size is extremely small; and their Bulk increases under the Eye, continually, till the Water is nearly evaporated.

In the Midst of the same Drop, and in several Places thereof, very different Figures will be likewise formed; particularly great Numbers of flat, thin, transparent, hexangular Bodies, *ccc*; some amongst which are thicker, as *e*; and a few appear more solid, and with six sloping Sides, rising to a Point as if cut and polished, *vid. d.*

The Figure *f* is composed of two high Pyramids united at their Base †. Some, in this kind of Form, are found truncated at one of their Ends, and others at both; but

†*Dr. Woodward* in his *Hist. of Fossils*, Vol. I. p. 222, says, That Grains of Tin, and the Crystals from it, in the Mines, are quadrilateral Pyramids: and this several of them now before me prove.

but then they appear like flat Bodies, not having the four Sides of a Pyramid ; as a few of them in the Drawing shew.—Several of the hexagonal Bodies may be observed with sloping Sides, forming a smooth triangular rising Plane, whose Angles point to three intermediate Sides of the Hexagon, *vid. g* : and some have a double Triangle, as another of the Figures shews.—*b* represents one of the solid Cubes.

These Crystals are presently destroyed by the Air, and converted into a Calx.

The Drawings in this Plate shew, that notwithstanding the seeming Affinity of the two Metals, the Configurations of *Salt of Tin* bear not the least Resemblance to those of Salt of Lead. In convulsive and epileptic Cases, *Salt of Tin* is given internally with good Success.

C H A P. XX.

ENS VENERIS.

AS Chemists give the Name of *Venus* to *Copper*, one would imagine their *Ens Veneris* to be a Preparation of that Metal: whereas it is in reality a Sublimation of the Salt of Steel or Iron * with *Sal Ammoniac* ;

I 4

and

* *Green Vitriol* is usually employed instead of *Salt of Steel*.

and therefore might be called *Ens Martis* with better Reason. It must however be acknowledged, that blue Vitriol was employed formerly instead of Salt of Steel; and *That*, being impregnated with Copper, rendered the Name less improper: but the *Ens Veneris* our Shops afford at present, has nothing of Copper in it.

It dissolves easily in Water, and gives to the Solution sated with it a Colour resembling that of Mountain Wine: which Colour its Crystals likewise retaining, appear (as they form before the Microscope) like the most beautiful *Chrysolites* or *Topazes*, seemingly cut with the greatest Elegance, in Shape as the *Plate* shews; and reflecting an extraordinary Lustre from their polished Surfaces, if the Candle be so shifted as to favour its being seen.

After the Solution has stood an Hour or two to settle, (for if used immediately its Foulness will prove inconvenient) a Drop thereof placed on a Slip of Glass, and warmed a little over the Candle, begins shooting from the Edges with solid transparent Angles, as (in the Drawing) *a a*. *Plate IV.* These, if only a gentle Heat has been given, will sometimes form, then dissolve, and afterwards form again.

The Crystals *b b* within the Drop, and underneath the same 1, 2, 3, 4, 5, 6, 7, are likewise best formed by a gentle Heat, and
may

may be discovered in the Fluid, when their magnified Appearance is no bigger than a Pin's Point, gradually increasing every Moment with regular Sides and Angles, polished Surfaces, and the Brightness of precious Stones. If too violent an Heat be given, instead of such Crystals, compound Figures will be formed, very suddenly, resembling that at *c*, consisting of parallel strait Lines, pointed with large solid Spear-like Heads of Crystal, along the Sides of which are placed, at right Angles, great numbers of small Crystals of the like Shape as the Drawing shews.—If the Heat has been little, though the same kind of Forms will be presented, they will not appear till the Moisture be nearly dried away, when they will shoot out with amazing Quickness. Some smaller Compositions are also not unusually seen, as at *d*.

But the Singularity of this Preparation is, that in some Part or other of the Drop, you will seldom fail to find a very regular and well-fashioned two-edged Sword of Crystal, forming under the Eye, in such Shape as *e* represents, though more exact and well-proportion'd : for suspecting such a Figure might be supposed imaginary, less Regularity has been, designedly, given it, than it will be really found to have. Sometimes two, three, or more, such crystalline Swords are seen in the same Drop.

The

The regular Crystals of this Subject soon lose the Sharpness and Elegance of their Form; but its compound Configurations, whose Beauty and Regularity are not to be conceived from Description, though when the Fluid is nearly evaporated they seem blunted and indistinct, yet afterwards, when the Moisture is quite gone, they recover their former Appearance, and may be preserved a long while, by the Method before directed, *p.* 36. *Salt of Amber*, and some other Salts, lose and recover themselves after the same Manner.

C H A P. XXI.

Flowers of ANTIMONY.

THE *Flowers of Antimony* are collected in form of a white Powder, from the Fumes of burning *Antimony*, by means of a Glass Vessel placed over it; and are supposed to contain the most active Salts and Sulphurs of that Mineral. The greatest Part of these Flowers when they are well stirred about in Water, sink to the Bottom thereof, leaving the Salts dissolved and suspended therein; and on placing a Drop of such Water on a Slip of Glass, and giving it a gentle Heat, numbers of slender
and

and extremely sharp-pointed *Spiculæ* will be seen forming at the Edges of the Drop, as Plate IV. *a a a*. At the same time minute Particles of the Powder that were also suspended in the Fluid, will be brought together by a mutual Attraction, and unite a little farther within the Drop, in Configurations resembling a fine Moss or Coralline, very beautiful and curious to behold: *vid. b b*.—The Middle of the Drop usually remains clear and void of every thing.

Antimony (the *Stibium* of the Ancients) is found in many Countries: it is composed of glittering, brittle *Striæ* like Needles, the Colour of polish'd Steel; sometimes running parallel to each other, and sometimes lying in different Directions.—If taken as a Medicine in its native Condition, it is supposed very harmless, occasioning no sensible Disorder in the Body: but, after the Chymist has tryed his Art upon it, it becomes capable of purging or vomiting with great Violence, even in a very small Quantity, and therefore should be administered with much Caution. Its Operation is however extremely uncertain; the same Dose at some times seeming to have no Effect at all, which, at other times will operate upwards and downwards in such Manner as to threaten the Patient's Life. This makes most Physicians afraid to meddle with the more elaborate
Prepa-

Preparations of it ; though 'tis generally acknowledged, that if the Manner of their Operation was certain, or their Violence could be sufficiently restrained, great Cures might be expected from them. Several *Nostrums*, exhibited in very small Doses, under different Forms, and cryed up as almost universal Remedies, are believed, not without Probability, to be Preparations of this Mineral ; from the like Uncertainty in their Operation, and the Violence wherewith they sometimes act.

As this Uncertainty is too notorious to be denied, the Dispensers of these Medicines plead, that the Manner of their Operation depends intirely on the Constitution and Distemper of the Patient, but always tends to produce a Cure : for, say they, if vomiting be most necessary, the Medicine will prove emetic, and that just so long and with such a Degree of Force as is requisite to bring away the morbid Matter ; on the contrary, if purging be more conducive to a Cure, the morbid Matter will be carried downwards ; and if the Disease requires neither purging nor vomiting, neither will be excited, but the Disorder will be cured by Perspiration or some other insensible Way. — The Truth of this I have nothing at all to do with, but refer the Consideration of it to those to whom it more properly belongs : permit

mit me only to observe, that whatever Drug can operate as this does, must be capable of producing great Good or Harm in animal Bodies, according as its Powers can or cannot be directed or regulated : and consequently, whoever can discover Means to correct its Violence, and render it a perfectly safe Medicine, will deserve greatly of Mankind.

I shall conclude this Head with taking Notice, that the Star-like Shootings on the *Regulus of Antimony*, about which some Chemists make much ado, are nothing more than the natural Configuration of its Salts*.

C H A P. XXII.

Corrosive Sublimate, and Arsenic.

MERCURY, purified Nitre, (or the Spirit of it) calcined Vitriol, and Sea-salt, are the Ingredients from which *Corrosive Sublimate*, or *Mercury Sublimate*, is prepared ; which is one of most violent and

* *Regulus of Antimony* made up in a proper Form and Size, is called the *Perpetual Pill*, because it receives very little Diminution, tho' carried through the Stomach and Bowels fifty times, and will purge every time take it as often as you please. *Antimonial Cops* are made likewise of this *Regulus*, which for a long Time will render Wine put into them emetic.

and deadly Poisons we know, lacerating and excoriating the Viscera, by its keen and active Spiculæ, till a Gangrene and Death ensue; unless proper Remedies are immediately used to prevent it.

A Drop of the Solution of this Sublimate in Water, appears by the Microscope to begin shooting from the Edges, as at *a*, *Plate IV.* immediately after which, different shaped Bodies are seen pushing onward towards the Middle; some quite strait and extremely sharp like the Points of Needles, others widening themselves towards their Extremities, and bending in such Manner as to resemble Razors with keen Edges: amongst these many are jagged and indented like Saws, some on one Side only, and some on both Sides; all which Particulars I hope the Drawing will render intelligible, *vid. b b.* Those that widen towards their Ends, stop their Progress, when advanced to the Condition represented: but such as are strait and tapering to a Point proceed very slowly towards the Middle of the Drop, and sometimes much beyond it, forming long Spikes most exquisitely sharp pointed, *vid. e e.* --- A few extraordinary Figures appear sometimes, serrated on both Sides, but in a contrary Direction, and ending with a very sharp Point, as is shewn at *c*: Others are likewise seen, now and then, having four Sides,
with

with keen Edges that run tapering to a Point, and form an Instrument like the long Head of a Spear exceedingly sharp-pointed, as at *d*.

When the Water is nearly exhale'd, another Sort of Configurations are formed very suddenly, consisting of innumerable little Lines disposed in a very curious and wonderful Manner, as the two Figures *ff* endeavour to represent. And often (though not always) one or two Configurations shoot out, when one would think all over, resembling what is shewn at *g*, but much more elegant and regular, and reflecting (I suppose from the extreme Thinness of the component Salts) with great Brilliance and Lustre, all the beautiful Colours of the Rainbow, if the Candle be placed to advantage. Which Circumstance, together with the Shape of this Configuration, induces me to call it the *Peacock's Tail*. The Configurations *ff* reflect Prism Colours also, but in a much less Degree of Perfection*.

The Compartment B is intended to shew, what happens frequently to this and many other Solutions, when a Drop is placed on a Slip of Glass, for Examination by the Microscope: that is to say,
some

* All these last mentioned Configurations appear like delicate Engravings, and afford the prettiest Sight imaginable.

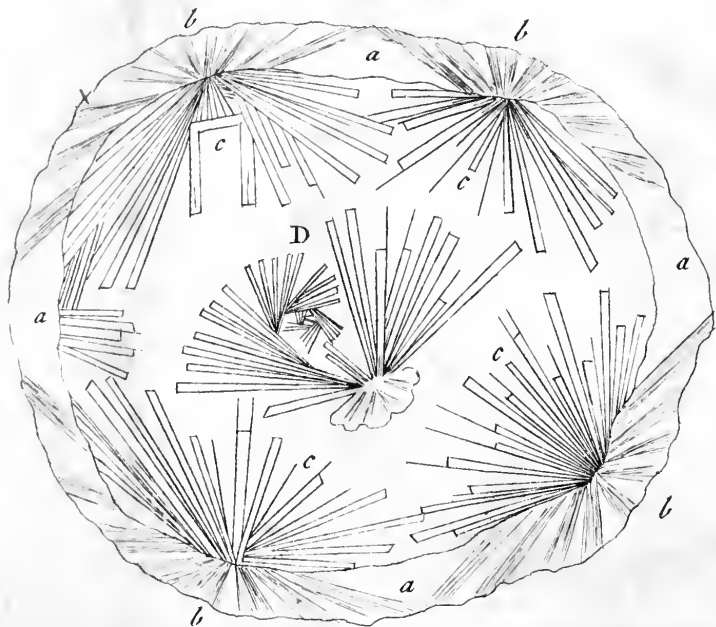
some small Part of the said Drop becomes so separated from the rest, as to make a sort of smaller Drop, wherein a more minute kind of Configurations are formed, upon the same Plan as the larger ones in the Drop itself. And this the Reader may conceive better, by viewing the Picture before him, than by any Description in my Power to give.

As *Corrosive Sublimate* and *Arsenic* are two Poisons nearly alike in their Operation and fatal Consequences, I think it best to treat of them together in this Chapter.

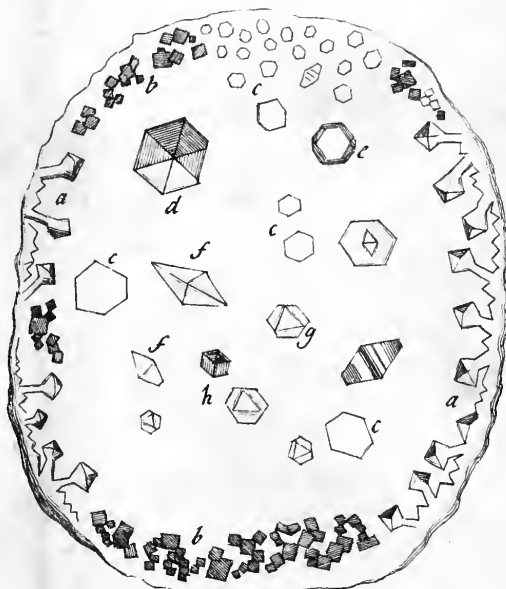
The Fumes that rise from * *Cobalt*, in making of *Smalt* from that Mineral, being collected under the Appearance of a whitish Soot, that Soot, by a farther Process, is converted into the common *White Arsenic*, which is what I now am speaking of. It is brought to us in flattish Pieces of several Pounds Weight, and when newly broken appears transparent like Glass or
Crystal,

* *Cobalt* is a hard and heavy mineral Substance, commonly of a blackish grey Colour, somewhat resembling the Ore of Antimony, but less sparkling and more difficult to break. Some of it has Spots of a purple or rather crimson Colour, which are called the *Flowers of Cobalt*. When roasted or calcined in a reverberatory Furnace with certain Proportions of Pot Ashes and common Salt, it produces a dark blue, glassy, or chrysaline Matter called *Zaffer* or *Smalt*, and the Fumes collected in this Process afford by different Management the *White, Yellow* and *red Arsenics*.

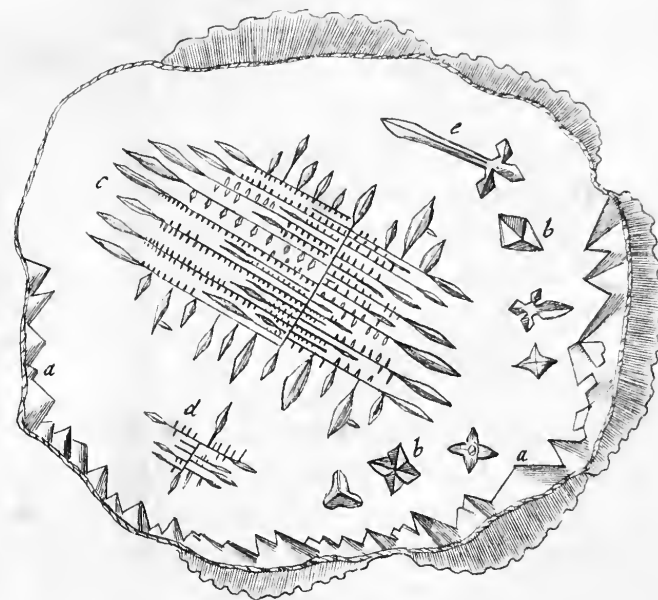
Plate IV. *pa. 128.* Salt of Lead.



Salt of Tin.



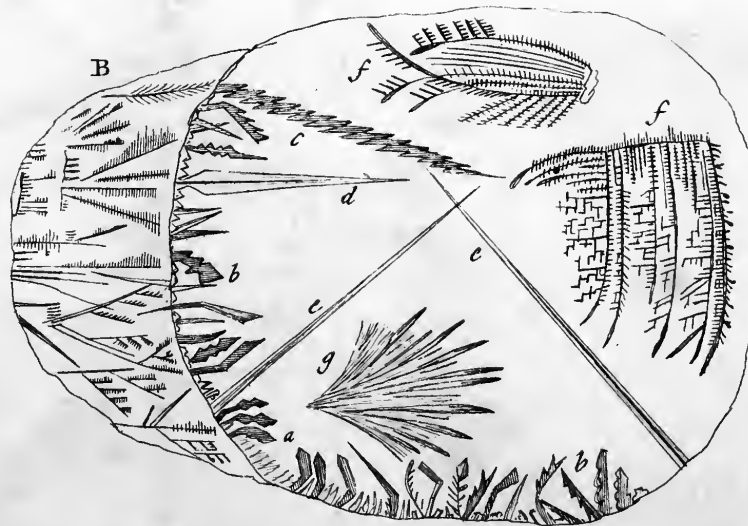
Ens Veneris.



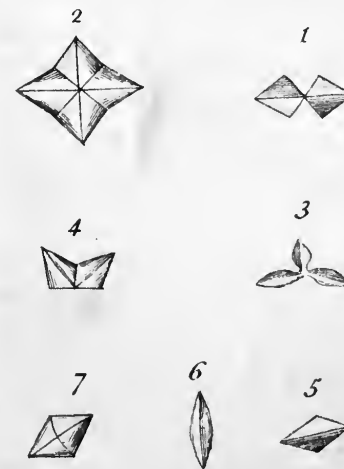
Flowers of Antimony.



Corrosive Sublimate.



Crystals of Ens Veneris.



Crystal, with a brownish Hue ; but after a few Days it becomes opaque, acquires a milky glossy Whiteness, and looks like white Enamel. When reduced to Powder it appears extremely white, and is frequently sold in the Shops by the Name of *Ratsbane*.

Notwithstanding this Substance certainly abounds with Salts, as its crystalline Appearance and its caustic and corrosive Qualities sufficiently evince, they are so sheathed or locked up (as the Chemists express themselves) in their Sulphurs, that they are very difficult to be separated and brought to view. Dr. *Mead* says, White Arsenic is intirely soluble, if one Part of it be sufficiently boiled in fifteen Parts of distilled or Rain Water †, which (with what I shall mention presently) gives me reason to imagine there may be a Difference in Arsenic, from perhaps a different Way of preparing it ; for notwithstanding I have boiled small Quantities, for a long while together, in much larger Proportions of Water, to the Consumption of the greatest Part, I always found most of the Arsenic at the Bottom undissolved. Nor amongst the Chemists could I ever obtain any of its Salts, which I was greatly desirous to examine by the Microscope *.

K

Some-

† *Mead* on Poisons, 3d Edit. pag. 217.

* A Physician of great Eminence gave me once a small semi-transparent brown Mass, shot out in Angles, which
a Chemist

Sometimes, indeed, in a Drop of the Water wherein Arsenic has been boiled, I have discovered a very few single Octaëdra, consisting of eight triangular Planes, or two Pyramids joined Base to Base; which undoubtedly is the true Figure of its Crystals, as I have since been fully convinced by the Assistance of an ingenious Friend, who found means to dissolve an Ounce of the *white crystalline Arsenic* in about three Pints of Water, of which, after evaporating a considerable Part, he brought a Phial-full to me. It was then a very clear and ponderous Liquor, without any Appearance of Crystals: but in a few Days, I found the Sides of the Phial, even as high as the Surface of the Liquor, pretty thickly covered with very minute Crystals, adhering firmly to the Glass, so as not easily to be removed, but distinct and separate from one another. On examining them with Glasses, I found them to be Octaëdra, uncommonly hard and insoluble. After near six Months I don't perceive their Size to be at all enlarged, or their Number to be increased. A Drop of the Solution,

a Chemist had presented to him as the true Salt of Arsenic, and I had great Hopes by this to have gratified my Curiosity: but when I came to try it, I found it absolutely insoluble, even in boiling Water, after its being reduced to Powder; and from its Appearance, its Hardness, and other Circumstances, I am very suspicious it was no other than common Spar.

Solution, examined on a Slip of Glass, either heated over a Candle, or left to evaporate of itself, notwithstanding its being sated with the Particles of Arsenic, produces no Configurations, and hardly any Crystals, leaving only a white Powder behind it upon the Glass: whose Particles, whilst the Water gradually evaporates, appear like minute Globules, even smaller than those of the Blood.

This *White Arsenic* is much more dangerous than the yellow or red, being a deadly Poison to all living Creatures: the Symptoms it brings on are much the same as those of *Corrosive Sublimate*, viz. Sickness, Fainting, Convulsions, cold Sweats, intolerable Heat and Thirst, Erosion of the Stomach and Intestines, Inflammation, Gangrene, and Death. But its Action is slower than that of Sublimate, for its Salts are so sheathed by its Sulphurs, that they begin not to operate, till those Sulphurs become rarified by the Heat of the Body, and set the Salts at Liberty; insomuch that a Patient may be saved after it has been swallowed half an Hour, by drinking large Quantities of Olive-Oil, or melted fresh Butter, or Lard, if Oil be not at hand, till by Discharges upwards and downwards, an Abatement of the Symptoms shews the Poison to be carried off. Salt of Tartar dissolved in Broth or Water, is also greatly com-

mended in this dangerous Case, along with the foregoing Remedies, as a Corrector of this Poison, and so likewise is Milk. The same Method is adviseable where Sublimate has been swallowed, but then it must be employed very speedily, or no Relief can be expected. After either of these Poisons has been discharged, drinking Milk for a few Days, and a gentle Purge or two, are very proper to compleat the Cure*.

The

* Dr. Blair, in his Letter to Dr. Mead on the Effects of *Arsenic* upon human Bodies, gives two remarkable Cases; the one of a Woman, who was killed by this Poison mixed with Flummery; which she eating about eleven o'Clock at Night, was seized immediately with violent Purgings and Vomitings, that continued till four o'Clock in the Morning, when she died convulsive. The Poison had been so well wrapt up in the Flummery, that on her being opened the Oesophagus was no ways altered: but the Doctor was surprized to find the Stomach so full of Liquor, having been informed she had eat or drank very little the Day before the Poison was given. It contained a greenish Substance, without any Colour or Appearance of such a digested Mass as uses to be in the Stomach, with several thick Coagula about the bigness of Walnuts, suspending some small quantities of a whitish gross Powder. When this Liquor was emptied, he found reddish and blackish Striae all over the Pylorus, being so many inflamed Lines resembling the Branchings of Blood-vessels, upon which the gross whitish hard Powder lay in such quantity, that after being well dried it weighed between a Scruple and half a Dram. All along the Intestines, as he laid them open down to the Anus, he found so much of the same kind of Liquor, without either Colour, Consistence, or Smell of an Excrement, as filled a Quart Bottle: which seemed extraordinary, considering the great Evacuations before her Death. He infers, that the Glands throughout the whole

Prima

The Fumes or Steams of Arsenic are exceedingly pernicious, and commonly distinguish themselves by an abominable stinking Smell like Garlic ; tho' *Otto Tachenius* says, in his *Hippocrates Chemicus*, that after many Sublimations of Arsenic, on opening the Vessel, he sucked in so grateful and sweet a Vapour that he greatly admired it, having never experienced the like before : but in about half an Hour, his Stomach began to ache and became contracted, a Convulsion of all his Limbs succeeded, he made bloody Urine with incredible Heat, was seized with Cholic Pains and cramped all over for an

K 3

Hour

Præ Via must have been most violently compress'd, to squeeze such Quantities of Liquor into the Stomach and Intestines.

The other Case is of a Lady, who on tasting (by Mistake) only so small a Quantity of *White Arsenic* as adhered to the Tip of her Finger, found herself within two Hours in great Disorder, grew faint, fell in a Swoon, and lost her Senses before she could be laid in Bed. A Physician being called, prescribed an Emetic, which made her vomit a large Quantity of such Sort of greenish Liquor as in the former Case ; after which she voided by Stool several Globules of greenish Coagulum, of the Bigness, Colour, and nearly the Consistence of Pickled Olives. These Discharges being over, and Alexipharmics given, she sweated plentifully, and slept well, and when she awaked her Skin was speckled with livid and purplish Spots. She recovered in a few Days, and became perfectly well. The Doctor observes, that these greenish Coagula are what *Arsenic* usually produces, when internally given ; the Knowledge of which may be of use to those who may have occasion to open Bodies, on Suspicion of their having been poisoned thereby. See *Blair's Misc. Observations*, pag. 62,

Hour or two; when these ugly Symptoms were taken away by his drinking Milk and Oil, and he became indifferently well: they were followed however by a slow Fever like an Hectic, which stuck by him the whole Winter, and of which he recovered very slowly by a proper Regimen in Diet †.

The extreme Subtilty and Penetrability of these Steams are remarkably manifest by their surprizing Effect in the Experiment
of

† *Glauber* tells us, in his *Treatise de Salibus*, that *Cobalt* and *Arsenic*, tho' violent Poisons, are yet harmless unless taken in Substance, but if exalted by a Sublimation with Salts and rendered volatile, the very Fumes of them will kill, as is well known to those who prepare the Water called *Aqua gradatoria* from a Mixture of Vitriol, Nitre and Arsenic, the least Vapour or Fume whereof instantly affects the Heart with the most horrid Tremors, and exceedingly disorders the Brain itself: a Candle will likewise be nearly extinguished in the saline Fumes thereof.

In *Dr. Mead's Mechanical Account of Poisons*, 3d Edit. pag. 225, are these Words, " I had once in my Possession, given me by an ingenious Chemist, a clear Liquor, which though ponderous, was so volatile, that it would all fly away in the open Air without being heated; and so corrosive, that a Glass Stopple of the Bottle which contained it, was in a short Time so eroded, that it could never be taken out. The Fume from it was so thin, that if a Candle was set at some Distance from the Bottle, upon a Table, the Heat would direct its Course that Way: so that it might be poisonous to any one that sat near to the Light, and to nobody besides." The Doctor very humanely conceals this Composition, lest an ill Use might be made thereof.

of the Ink called Sympathetic †. A Grain of Arsenic will also convert a Pound of Cop-

K 4

per

† As some of my Readers may possibly not know the Experiment here referred to, I shall give it by Way of Note, which those acquainted with it may if they please pass over.

Orpiment half an Ounce, and one Ounce of Quicklime, being powdered separately, then mix'd together, and put into a Matras with five or six Ounces of Water, stop the Vessel close, and digest in a gentle Sand Heat for ten or twelve Hours, shaking the Mixture often. The Liquor, when settled, will be very clear.

This being prepared, write, with a strong Solution of *Saccharum Saturni* made in common Water, on a Piece of clean Paper, and when it is dry nothing will be seen at all. Put the Paper with this invisible Writing between the very beginning Leaves of a Book; then with a Brush or Piece of Sponge, dipt in the Liquor prepared with Orpiment, wet another Paper, and place it at the End of the same Book, opposite to the first Paper. Shut the Book nimbly, and with your Hand strike on it two or three smart Blows; and if it be very thick squeeze it in a Press, or sit upon it a few Minutes; after which, on opening the Book, you'll find the invisible Writing black and legible, by the subtile Penetration of the Steams of the Orpiment through all the Leaves.

Quench burning Cork in Spirit of Wine, and when 'tis finely powdered make Ink, by mixing a sufficient Quantity of it in Water a little thickened with Gum. Write on a Paper with the Solution of *Saccharum Saturni*, and when 'tis dry and invisible, write again upon the same Place with your Cork and Water which will appear like common Ink; when 'tis dry rub it over with some Cotton wetted in the Preparation of Orpiment, and immediately the Writing that was visible will disappear, and the invisible Writing will present itself very legible instead thereof. These are pretty Experiments, which I several times have tried; but they should be made in the open Air, and with great Caution, the Fumes of the Orpiment stinking most abominably, and being productive of great Mischiefs if taken into the Lungs.

136 *Experiments how to know Arsenic.*

per into a beautiful Resemblance of Silver, but renders it brittle at the same Time.

Otto

ARSENIC being the Poison most commonly made use of by wicked People to destroy others, and by despairing Wretches to put an End to their own Lives, I shall I hope be excused, for adding this Note of instruction how to make Tryal of any Substance suspected of being *Arsenic*: and likewise how to judge of the Symptons it produces when taken; collected from the recent unhappy Case of Mr. *Blandy*.

This Gentleman was poisoned by Arsenic, given him by his own Daughter in Water Gruel; at the Bottom of a Pan of which a Servant Maid finding an unusual white gritty Substance, and suspecting Mischief, from having seen her Mistrefs stirring something into it, she shewed it to an Apothecary, who saved a little Quantity of the Sediment, which was dryed, and examined by Dr. *Addington*.

The Doctor's Account of *White Arsenic* upon the Trial of Miss *Blandy*, was, that when powdered it has a Milky Whiteness, is gritty and almost insipid. Part swims on the Surface of cold Water like a pale sulphureous Film, but the greatest Part sinks to the Bottom, and remains there undissolved. Thrown on red hot Iron, it does not flame, but rises intirely in thick white Fumes, which have the Stench of Garlic, and cover cold Iron held over them with white Flowers. The Powder he examined did exactly the same.

He boiled ten Grains of powdered Arsenic in four Ounces of clean Water, which he filtered, divided into five equal Parts, and put into as many Glasses.--On pouring into the first Glas a few Drops of Spirit of Sal Ammoniac, it threw down a few Particles of a pale Sediment. Some Lixivium of Tartar poured into the second, produced a white Cloud, hanging a little above the Middle of the Glas. Strong Spirit of Vitriol poured into the third, made a considerable Precipitation of a lightish coloured Substance, which hardened into glittering Crystals, sticking to the Sides and Bottom of the Glas. Spirit of Salt poured into the fourth, precipitated a lightish coloured Substance. Syrup of Violets in the fifth, produced a beautiful pale green Colour.—Ten Grains of the Sediment from the Gruel, tryed in the same Manner, afforded the same Appearances exactly.

The Symptoms produced by this Poison in Mr. *Blandy*, were burning and pricking in the Tongue, Throat, Stomach and Bowels, Sicknes, Gripings, Vomiting and Purging, bloody

Otto Tachenius says, that Silver may be obtained from Tin by Arsenic.

C H A P.

bloody Stools, Excoriation of the Fundament, Swelling of the Belly, exquisite Pains and Prickings in every external as well as internal Part of the Body, which he compared to an infinite Number of Needles darting into him all at once, Uneasiness in the Mouth, Lips, Nose and Eyes; Lips dry and rough with angry Pimples on them, inside of the Nostrils in the same Condition, the Eyes a little Bloodshot; cold Sweats, Hiccup, extreme Restlessness and Anxiety, low trembling intermitting Pulse, difficult unequal Respiration, Difficulty of Speech, Inability of Swallowing, and (the Consequence of all these cruel Symptoms) Death.

Dr. Addington and Dr. Lewis on examining the dead Body, found it in the following Condition, *viz.* The Back, hinder Part of the Arms, Legs and Thighs, were lived. The Fat on the Muscles of the Belly of a loose Texture, inclining to a State of Fluidity; the Muscles themselves pale and flaccid. The Cawl yellower than natural, and on the Side next the Stomach and Intestines, brownish. The Heart variegated with Purple Spots; and no Water in the Pericardium. The Lungs like Bladders filled with Air, and blotted as it were in some Places with pale, but in most with black Ink. The Liver and Spleen much discoloured: the Liver looked as if boiled, but that Part which covered the Stomach particularly black. The Bile fluid, of a dirty yellow inclining to red. The Kidneys stained all over with livid Spots. The Stomach and Eowels inflated, and appearing before any Incision, as if pinched and extravasated Blood had been stagnated between their Membranes. They contained nothing, as far they were examined, but a slimy bloody Froth: their Coats remarkably smooth, thin and flabby. The Wrinkles of the Stomach totally obliterated: its internal Coat and the Duodenum prodigiously inflamed and excoriated.—Vid. *Miss Blandy's Tryal*, Folio, pag. 12, 13, 14, 15.

As *Arsenic* is not used in Medicine, it would be well if the Apothecaries and Chemists did not keep it in their Shops. Selling now and then a Pennyworth to kill Rats, (and even in doing that many sad Accidents have happened) can surely induce no good Man to risk the Possibility of putting this horrid Poison into wicked Hands.

C H A P. XXIII.

SALT of AMBER.

THE pretty Shootings of this extraordinary Salt are exceedingly entertaining, though its Progressions are so very slow, that some Patience is necessary to wait for and attend to the whole Course of its Configurations : but a curious Observer will find from it at last a Pleasure sufficient to reward his Attention.---Its first Shootings at the Edge of the Drop, after it has been held for a few Seconds over the Flame of a Lamp or Candle, appear irregular, as at *a a*, Plate V. Some Figures push out soon after, beyond the rest, and are curved and tapering to a Point, as *b b*. Very elegant Figures will be seen forming themselves in other Places at the same time, and resembling Sprigs of Fir or Yew : Numbers of these rise together, each having a main Stem very thickly beset with little Shootings from Top to Bottom, in some on both Sides, but in others on one Side only ; which Difference will be understood by a View of the Figures *c c*. The downy Feathers of Birds appear in the same Kind of Form when examined by the Microscope. As the Progression goes on, Branches will be found issuing from the Sides of the former Shootings, *vid. d* : and in some Places of the Drop several Gradati-

ons

ons of Branchings will be perceived to succeed one another, to divide and subdivide after a most wonderful Order, representing at the last a Winter Scene of Trees without Leaves, a Specimen of which is shewn at *e*.---The last Action of this curious Salt produces Figures exquisitely delicate, bearing no Resemblance to any thing that preceded, but appearing like the Flourishes or Engravings of a Masterly Hand, in the Manner represented at *f f*. This Part of the Operation begins not till the Water is nearly exhaled, and whilst it is performing the Scene appears a good deal confused ; but after waiting till the Water is intirely dryed away, a thousand Beauties will present themselves perfectly distinct and clear ; for the Configurations of this Salt do not break away, or melt in the Air, as most others do, but may be preserved on the Glass Slip for a long while afterwards, if so be nothing is suffered to rub them off.

It would give me great Pleasure, was it possible, from the Configurations of this Salt, to trace out, with any Degree of Certainty, the Generation or Production of Amber ; a Subject about which *Naturalists* are exceedingly divided and perplex'd : Some supposing it an animal Substance, others a resinous vegetable concreated Juice, and others a natural Fossil or Mineral : but the Shootings of its Salt are so very different from every other Kind, that
they

they afford little or no Ground on which to raise a Conjecture : however, the general Figures round the Edge have I think a Sort of mineral Character, and the Feather-like Bodies tend a little towards the Shootings of some of the Vitriols. The curved single Lines *ff*, which appear like Drawings with a Pen, are so peculiar to this Salt, that, for want of finding them elsewhere, one can form no Judgment from whence they derive their Form ; and the Case is the same as to those Shootings which resemble naked Trees. I shall not pretend therefore to infer any thing from these Figures : but, before I intirely quit the Subject, shall present a few *Queries* to the Consideration of my curious Readers.

Quere 1st. Does not Amber when analyzed, afford a considerable Quantity of Oil, in Smell, Colour, Inflammability and Consistence like the White or rather Amber-coloured *Naptha*, a Proportion of *Acid Salt*, and a *Caput Mortuum* or Earthy Substance ? and, if so, does it not seem probable, that such a bituminous Oil fixt by an acid Salt, with more or less of an Earthy Substance, is really the Composition of Amber * ?

Quere

* In the Distillation of Amber there first rises a thin limpid Oil, then an Oil yellow and transparent, which is succeeded by a volatile acid Salt and a red Oil somewhat cloudy: a gross fat Oil like Turpentine comes over next, and last of all a thick black Matter. At the Bottom remains a small Quantity of a *Caput Mortuum*. Vid. *Boerhaave's Analysis of Amber*, Vol. II^d of his Chemistry, Process 87. *Hartman* obtained an Ounce of Volatile Salt from 1 L of white Amber, whereas 1 L of yellow afforded scarce a Dram.

Quere 2d. If it be inquired, where these Materials are to be found, and how they can be brought together? may it not be answered, that in some Countries, and particularly in *Persia*, near the *Caspian Sea*, there are Springs where *Naptha* rises out of the Bowels of the Earth; and that the Ground thereabouts is so saturated therewith, that, on scraping off the Surface, and applying a Candle near it, a Fume arising therefrom immediately takes Fire, and continues burning, with a clear and constant Flame, until it becomes extinguished by throwing Earth upon it, or smothering it by some other Means †? If therefore, such bituminous Oil

† Two Letters now lie before me, with Accounts of these *Naptha* Springs; one from Dr. *James Mounsey*, Physician to the Army of the *Czarina*, the other from *Jonas Hanway*, Esq; both Gentlemen, who by their Travels, their Residence in *Muscovy*, and their Acquaintance with several People who have been upon the Spot, have had great Opportunities of becoming perfectly informed of every thing relating to this Subject; and whose Judgment and Veracity may be depended on. Both their Accounts agree, that on the Western Coast of the *Caspian Sea*, not far from the City of *Baku*, there is a large Spot of Ground, where, on taking off 2 or 3 Inches of the Surface of the Earth, and then applying a live Coal, the Place uncovered catches Fire, even before the Coal touches the Ground, and sends forth a light blue Flame, which goes not out unless it be smothered by throwing Earth, or some thing else upon it. This Flame makes the Earth hot, but does not consume it. If a Tube (even of Paper) or a Reed be set about two Inches in the Ground, and made close below with Earth, on touching the Top of it with a live Coal, and blowing, a Flame immediately issues forth, without burning either the Reed or Paper, provided the Edges be covered

Oil be found, and in sufficient Quantity, our next Enquiry will be concerning the Acid Salt : as to which, are not the Chemists pretty generally agreed, in supposing, that what they call a *Vague Acid* (whereby they mean, if

covered with Clay. This method supplies the want of Candles in their Houses. Three or four of these Canes will also boil Water in a Pot, and they dress their Victuals with it. The Flame may be blowed out like that of a Lamp, but otherwise it continues burning; it smells somewhat sulphureous, or rather like *Naptha*, but very little offensive. The Ground is dry and stony, and the more stony the Ground the stronger and clearer the Flame. Near this place they dig Brimstone, and here are also *Naptha* Springs. But the chief Place for *Naptha* is *Szwieten* Island, a small Tract of Land on the Western Coast of the *Caspian* Sea, and uninhabited, except at such Seasons as they fetch *Naptha* from thence : which the *Persians* load in their wretched Embarkations without Barrels or any other Vessels, so that sometimes you see the Sea covered with it for Leagues together. The Springs boil up highest in thick and heavy Weather, and the *Naptha* sometimes takes Fire on the Surface, and runs lighted or burning into the Sea in great Quantities, and to great Distances. In clear Weather it does not bubble up above two or three Feet. People make Cisterns near the Springs, into which they convey what overflows by Troughs, taking off the *Naptha* from the Surface, under which there is a mixture of Water or some heavier Fluid. The greatest part is of a dark grey Colour, very unpleasent to the Smell, but used in Lamps by the poorer Sort. There are also Springs of black *Naptha*, which is thick, and on Distillation grows not clear but yellow ; but the most valuable is the white *Naptha*, which is naturally clear and yellowish and bears a great Price. The *Russians* drink it as a Cordial, but it does not intoxicate : it is used also for Pains or Aches, and is carried into *India* as a great Rarity, where they make with it the most beautiful and lasting *Japan* that has ever yet been known.

What the *Indians* call the *Everlasting Fire*, lies about ten English Miles, N. E. by E. from the City of *Baku*, on dry rocky Ground. There are several ancient Temples built with Stone, supposed to have been all dedicated to Fire ; most of them

if I understand them aright, a volatile subtle Vapour, Fume or Spirit) exists in the Bowels of the Earth, and throughout the Atmosphere near the Surface thereof; and that by pervading, intermixing, or concretizing with different Substances, it composes Vitriol,

them are low arched Vaults, from 10 to 15 Feet high. Amongst the rest there is a Temple in which the *Indians* now worship; near the Altar, about three Feet high, there is a large hollow Cane, from the End of which issues a Flame, in Colour and Gentleness not unlike a Lamp that burns with Spirits. The *Indians* affirm, this Flame has continued burning some thousands of Years, and believe it will last to the End of the World, and that if it was resisted or suppressed in this Place, it would rise in some other. By the Number of Temples it is probable here were formerly a great Number of Worshippers of Fire, as well *Indians* as *Persians*: they are called *Gouers*. At present here are only about twenty Persons, who reside constantly, and go almost naked. In Summer it is very hot, and in Winter they dwell within doors, and can keep what Fire they please in the Manner above described: they live upon Roots and Herbs for the most part, and are supposed to attend as Mediators for the Sins of many who are absent: and by their Application to this Fire, in which the Deity is supposed to be present and visible, they atone for the Sins of others. A little way from the Temple just now mentioned, near *Baku*, is a low Cliff of a Rock, in which there is an horizontal Gap 2 Feet from the Ground, between 5 and 6 long, and about 3 Feet broad, out of which issues a constant Flame, much of the Colour mentioned already, being a light blue. It rises sometimes 8 Feet high, but is more low in still Weather. They don't perceive the Rock wastes in the least. This also the *Indians* worship, and say it cannot be put out. About 20 Yards on the back of this Cliff is a Well, in a Rock 12 or 14 Fathoms deep, with exceeding good Water.

The curious Particulars contained in this Digression will 'tis hoped excuse its being inserted.

I received with these Letters some of the white *Naptba*, which in Colour, Smell and Taste resembles much the finest kind of Oil of Amber.

Vitriol, Alum, Nitre, and several Metallic and Mineral Bodies? May it not then be imagin- ed possible for this same acid Vapour so to mix with and consolidate such bituminous fossil Oil, or Naptha, as thereby to produce Amber?

Quere 3d. Is there any thing in the Appearance of Amber, or in the Places where it is found, that may conduce towards forming some probable Conjecture concern- ing the Production of this Body *?

Quere 4th. Do not the several Species of Insects found in Amber, prove, beyond all Dispute, that it must have been in a fluid State at the Time those Insects were in- tangled in it? Are not the Springs or Oozings

* We are told, that where Amber is met with in Quan- tity, there is likewise constantly an Abundance of Vitriol. No Country yet known affords more or better Amber than *Prussia*, where it lies, as *Hartman* says, in a Kind of Stra- tum or Bed, intermixt with a Substance resembling fossil Wood or Bark, but whose Origination he imputes to a fat bituminous Earth: Vitriol and Bitumen are also here in Plenty, and he was informed there are Springs of Oil rising out of the Ground; from all which Circumstances put together, his Conclusion is, that the Exhalations of Bitu- men (from a subterraneous Heat) are collected into Drops; that the same Heat pervading the neighbouring Salts, car- ries their Effluvia along with it, and mixes them with the bituminous Drops; whence he supposes, that the saline Spiculæ fix the Bitumen and produce Amber, which is more transparent, better scented, and firmer, according to the Purity and Proportion of the bituminous and saline Exhalations. Vid. *Phil. Transf.* No. 248. May not some of the fossil Oil here mentioned be as easily supposed to have been fixt by the saline Effluvia or Spiculæ?

ings of Naptha out of the Earth in Places where Insects might be likely to fall into it? Supposing which, might it not perhaps have been hardened or congealed by the acid Vapour soon after their being so intangled? though that is not absolutely necessary, since Naptha will preserve Animal Bodies a great Length of Time. Is it not found on Tryal, that the Wings, Horns, Legs, &c. of very small Creatures spread and extend themselves much better in Naptha, or fine Oyl, than in Water or any watry Fluid? and may not this account, in some measure for the Perfection in which some very small Insects appear, when embodied in this Substance?

Quere 5. As the Earth affords bituminous Fluids different in Colour, Consistence and Purity, may not white Naptha (so called, tho' of a pale yellow,) which is the most pure of all, be supposed capable of being concreted into the best and clearest Amber? may not a coarser and browner Naptha compose Amber more indifferent? and may not a black Kind be converted by the same Chemistry of Nature into Jet and Asphaltum?

Quere 6. Is it wholly improbable that some bituminous Juice, or fossil Pitch, mixed and concreted with Earth, or perhaps some other Matter, may be the Composition of Coal? and should it be inquired

where an acid Spirit can be found for the fixing and consolidating these Principles? do not the *Choak Damps* in most Coal Pits prove the Existence of such a Spirit within the Bowels of the Earth? do not the *Fire Damps*, frequent in the same Pits, likewise prove the Abundance of a bituminous Vapour inflammable like *Naptha*?

Quere 7. Do not the Brittleness and Lightness of Coal, Jet, and Amber, somewhat countenance the Opinion of their being of an oily and bituminous Composition? and if so, what Fluids does the Earth afford so likely to constitute these Substances, as † *fossil Pitch, Petroleum, Oleum Terræ*, and the different Sorts of *Naptha*?

C H A P.

† Captain *John Peyntz* in his Account of the Island of *Tobago*, pag. 38. says, “ *Green Tar* issues out of the Earth from the *Munjack Rocks*, and is commonly gathered after a shower of Rain, by skimming it off from the Surface of the Water: then putting it into a great Gourd, or such like Vessel, that has an Hole at the Bottom, they separate the Oil from the Water, by suffering the Water to slide gently out; but when the Oil appears, they cautiously stop and preserve it for several Uses, as to burn in Lamps, &c. The *Munjack* is nothing else than a Confirmation or Coagulation of the Tar (we spoke of) into a more solid Body; which *Munjack* were it in a frigid, as it is in the torrid Zone, would be absolute Coal, such as we burn in *England*.”

C H A P. XXIV.

Of SCARBOROUGH SALT.

WHAT I am now about to treat of under the Name of *Scarborough* Salt, was bought at one of the principal WaterWarehouses in *London*, at a good Price; and was affirmed by the Seller to be a true and genuine Salt prepared from the *Scarborough* Well.

Some of this being dissolved in Water, a Drop of the Solution begins shooting from the Edges: first of all, in Portions of quadrilateral Figures, much like those of common Salt; but their Angles instead of 90 are of about 100 Degrees. These Figures shoot in great Numbers round the Borders of the Drop, having their Sides as nearly parallel to one another as the Figure of the Drop will allow: some proceed but a little Way, others farther before they renew the Shoot, *vid. a a, Plate V.* In some Places they appear more pointed and longer, as at *b*, and sometimes instead of the Diagonal, one of the Sides is seen towards the Edge and the other shooting into the Middle, as *e*.

The inward Configurations seem to owe their Forms mostly to Vitriol, and are all produced by the same Method of Shooting: though some proceed from the Figures al-

ready formed at the Edges, and others from original Points rising in the Fluid, and intirely detached from the Sides of the Drop. The former are produced by the sudden Elongation of such Figures as *b*, or *c*, into one long Spike or Stem, which in its Progress sends forth *Spiculæ* from its Sides, ranged close to one another, sometimes nearly at right Angles to the main Stem, as at *e*, and at other times obliquely thereto, those on the one Side shooting upwards, and those on the other downwards, in regard to the Foot of the Stem, as at *d*: the whole Number of the *Spiculæ* on each Side of the Stem forming a right angled, or an oblique angled Triangle. From the lowest of these *Spiculæ* are frequently seen others of the same Kind proceeding, but their Direction, in respect to the Branch they rise from, seems not wholly correspondent to the Direction of the said Branch in respect to its main Stem, being sometimes alike and sometimes unlike thereto, *vid. d e*.

The other Figure which the Middle produces is of a like Kind with those last described, but shoots from a single detached Point (for the most part) into four Branches, which are generally tho' not always oblique to one another, as at *f*.

C H A P. XXV.

CHELTENHAM SALT.

WHEN this Salt is prepared for Examination by Solution, its first Shootings at the Edge of the Drop are Radiations, (from a Number of very small Centers,) which spread till they meet each other, whereby their Progress is for a while impeded ; but other Shootings soon begin from the Extremities of these, and proceed by small Steps and Renovations represented at *a*, *Plate V*. These Figures, however, frequently dissolve again and disappear, and in their Places larger ones of the same Kind arise, as from their Ruins, somewhat in the Form of Brushes, *see b*. Small Ramifications like the Branches of some of the Species of Moss shoot frequently from the Tops of these, as *c* attempts to shew.---But all the above mentioned Figures, which a small Degree of Heat produces, seldom occupy more than one side of the Drop : the more solid Configurations which generally take up the other Side, not forming till near the End of the Operation. In the mean time great Part of the Middle of the Drop becomes filled with many small Figures, which appearing first as Points, rising under the Eye imperceptibly, shoot every Way after-

wards into very pellucid and beautiful Ramificationous, as *d d*. Some Figures owing their Form to common Salt, like that shewn at *e*, are usually the Fore-runners of another Kind of Configuration arising from the same Principle, which shoots pretty suddenly, and appears not much unlike the Covert Way and the Glacis or outward Slope of a fortified Place, *vid. ff*.

This Salt was bought at the same Place as the foregoing, and with the same Assurance of its being genuine. When kept a little while it crumbled into a white Calx or Powder, though it was at first in very fair Crystals.

C H A P. XXVI.

EPSOM SALT.

A Drop of the Solution of this Salt begins to shoot from the Edge in jagged Figures like those shewn at *a*, *Plate V*. From other Parts of the Edge different Configurations extend themselves towards the Middle, some whereof have fine lines proceeding from both Sides of a main Stem, in an oblique Direction, those on one Side shooting upwards in an Angle of about 60 Degrees, and those on the other downwards in the same Obliquity, as at *c* and *f*. Others produce Jaggs
from

from their Sides nearly perpendicular to the main Stem, thereby forming Figures that resemble the Branches of some Species of *Polipody*: these are represented at *e*: but in others the Jaggs are shorter, *vid. d.* Now and then one of the main Stems continues shooting to a considerable Length, without any branchings from the Sides, but at last sends out two Branches from its Extremity, as at *g*. Sometimes a Figure is produced having many fine and minute Lines radiating from a Center, in the Manner shewn at *b*. The last Shootings in the Middle of the Drop may be seen at *b*, and are not unlike the Frame Work for the flooring or roofing of an House, but with the Angles a little oblique: and sometimes a Form presents itself like that shewn at *i*.

All these Figures must be produced with a very small Degree of Heat, for if the Drop be made too hot the Salt will not shoot at all: but when once the Configurations are formed, the Salts fix, become smooth and hard like Glass, and may be preserved a long time.

The Subject above described was not the true Salt of the *Epsom Waters*, which I knew not where to get; but it was I believe some sort of Preparation like what is commonly sold under the Name of *Epsom Salt*, at a very cheap Rate: though I gave a much

larger Price for this, on its being recommended as a much better purging Salt. *

Acton Salt, or what I bought for such, appeared on Examination just like the above, but without the Figures *b i g*.

C H A P. XXVII.

SAL POLYCHRESTUM.

A Solution of this Salt when heated begins to shoot near the Edges of the Drop, in Ramifications as at *a*, Plate V, or in

* Dr. *Quincy*, in his English Dispensatory, remarks what was then sold for the Salt of *Epsom Water*, as an abominable Cheat. (*vid.* Edit. 8th pag. 355.) He informs us, that Dr. *Greaw*, having found by Experiment, that a Gallon of Water would, on Evaporation, afford about two Drams of Salt, endued with the Cathartic Quality of the Water: gave an Account thereof in Latin to the *Royal Society*. Upon which a certain *Chemist* pretending to make large Quantities for Sale, put off a fictitious Preparation for the true Salt of *Epsom Purging Waters*; and others attempting the same Thing, the Price was soon brought so low, that instead of one Shilling per Ounce, under which the true Salt could not honestly be made, their fictitious Kind was sold at not much above 30 Shillings per Hundred Weight, which little exceeds three Pence per Pound. And Dr. *Brownrigg* assures us, in his excellent Treatise on the *Art of making common Salt*, pag. 88. that all the Salt now vended under the Name of *Epsom Salt*, is prepared intirely from the *marine Bittern*, at the Salt Works nigh *Newcastle*, and at those at *Lymington* and other Parts of *Hampshire*; which *Bittern* is a saline Liquor, of a sharp and bitter Taste, left at the Bottom of the Salt Pans after the Salt is made and taken out. *Vid.* pag. 62.

in the Figures shewn at *b* : but if only a small Degree of Heat be employed, it forms many very transparent Parallelograms, some having one, and some more of their Angles canted, as at *c*.

This Salt is a mixture of Nitre and Sulphur in equal Quantities, set on fire in a Crucible by a Spoonful at a Time, afterwards dissolved in warm Water, filtered and evaporated. It purges by Stool and Urine.

C H A P. XXVIII.

GLAUBER'S SALT.

AFTER the Distillation of *Spirit of Salt with Oil of Vitriol*, (from Oil of Vitriol, Common Salt and Spring Water, in equal Quantities;) what Salt remains at the Bottom of the Retort, being dissolved, filter'd, evaporated and crystalized, is called *Glauber's wonderful Salt*.

A Drop of Water saturated with this Salt, and gently heated over a Candle, produces Ramifications from the Side of the Drop, like the Growth of minute Plants, but extremely transparent and elegant, in the Manner shewn at *c*, *Plate V*. Some of them however begin to shoot from a Center at some Distance from the Edge, protrude Branches from

from that Center in a contrary Direction, and appear somewhat like a Bundle of Grass or Twigs tyed together in the Middle, as at *b*; they likewise shoot sometimes from one and sometimes from more Sides of the central Point, in the Varieties shewn at *d*.

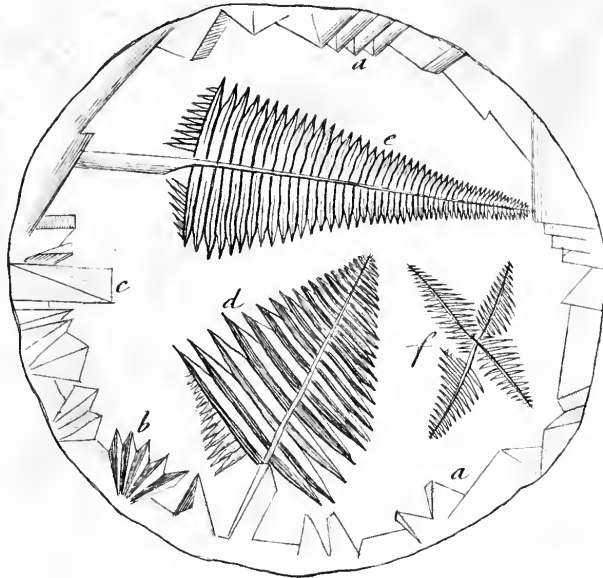
Other Figures are produced from different Parts of the Edge of the Drop, as at *a* and *f*, as also the parallel Shootings at *e*: but the most remarkable and beautiful Configuration forms itself last of all near the Middle of the Drop: it is composed of a Number of Lines, proceeding from one another at right Angles, with transparent Spaces and Divisions running between them, appearing all together like Streets, Alleys and Squares, as represented at *g g*. --- This Figure plainly owes its Original to Marine Salt, and is of the same Kind with that shewn at *f f*, in the *Cheltenham* Salt. The Figures *a* and *e* are vitriolic.

When this Configuration begins, it forms with wonderful Rapidity, affording the Observer a very agreeable Entertainment: but he must watch it carefully, for as it is produced almost instantaneously, its Beauty is of a very short Duration: in a few Moments it dissolves and breaks away like melted Ice, which renders the drawing of it very difficult. The Figure in the Plate was taken at several Times and with different Drops,

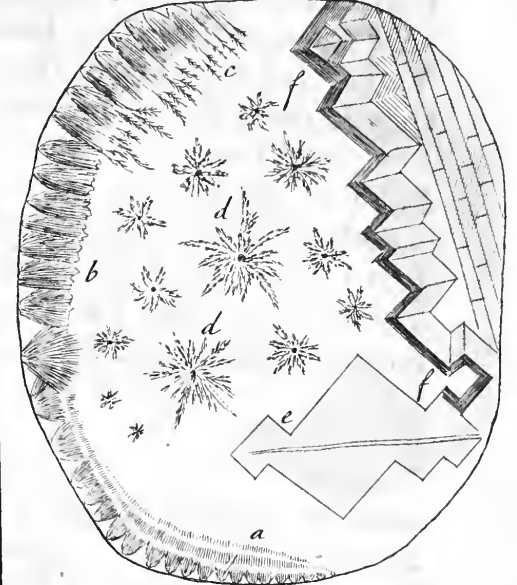
Pl. V. p. 154. Salt of Amber.



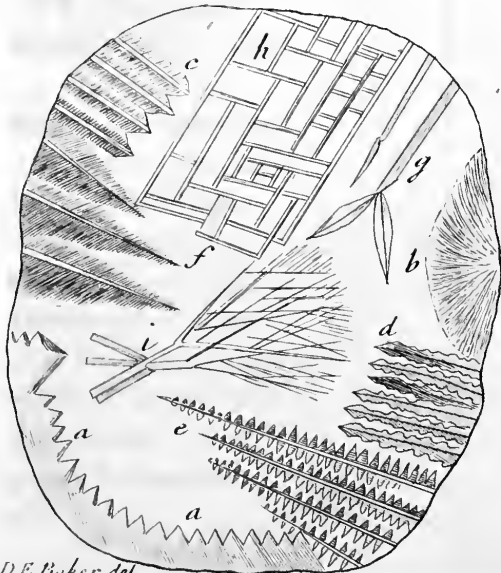
Scarborough Salt.



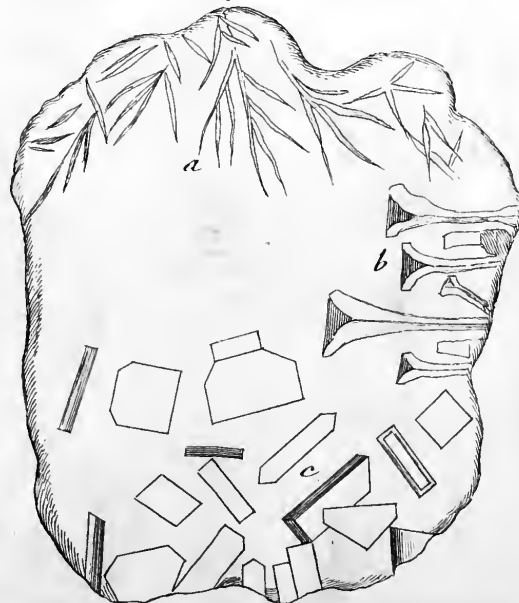
Cheltenham Salt.



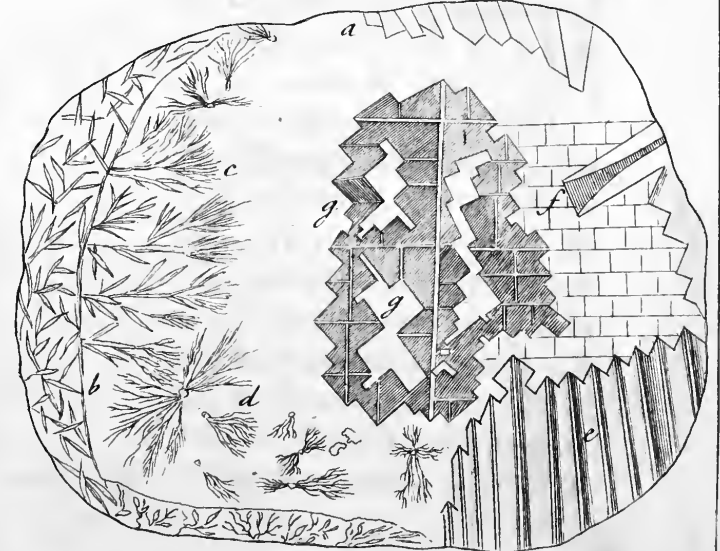
Epsom Salt.



Sal Polychrestum.



Glauber's Salt.



D.F. Baker del.

J. Mynde sc.

in order to collect together and represent the general Idea of it.

If the Solution be not heated in the Bottle, to dissolve the Sediment it throws down, little will appear but the Brush-like Figures.

Glauber's Salt is reckoned to answer the Intention of most purging Waters : it promotes Evacuation both by Stool and Urine, and may be so made as to be less nauseous than most other artificial purging Salts.

C H A P. XXIX.

SALT OF TARTAR.

AFTER heating a Drop of the Solution of this Salt, there arise in many Places, near its Edges, numbers of minute Bodies, pretty irregular in their Form, but mostly inclining to be triangular ; as may be seen in the Drawing, at the Side *b*. (*see Plate VI.*) Several of these appear likewise farther within the Drop, and produce all the Variety of Figures *cc*, *dd*, &c.--There shoot at the same time, from some Parts of the Edge, transparent Bodies with parallel Sides terminating as at *a*, some whereof are strewed over with the little Triangles before described. From other Parts of the Edges branched Figures present themselves, resembling small Shrubs, (*vid. f*) whose Twigs are
naked

of Tartar and those of Pearl Ashes, or any other of the lixivial Salts of Plants, all which they suppose to receive alike the same Qualities from the Fire : but the contrary to this will I believe be manifest, from an Examination of the Salts I am going to submit to the Reader's Judgment ; the Configurations and Crystals whereof are so widely dissimilar, that one can hardly conceive them to arise from exactly the same Principles in the Salts themselves, or to produce exactly the same Effects when applied to other Bodies. 'Tis indeed probable that the essential Salts of Plants, collected in the Form of Crystals, from the Juices of their respective Plants, without the Help of Fire, may be different from the Salts of the same Plants procured by Incineration, and may have different Virtues : but I think such essential Salts can hardly differ more from one another, when examined by the Microscope, than the lixivious Salts of different Plants are found to do ; and consequently that these lixivious Salts must have Virtues very different from one another.

The making essential Salts being a troublesome as well as tedious Operation, and considered only as a Matter of Curiosity, none of the Shops could afford me any of them ; and even of the lixivious Salts, the Opinion of their being all alike has so much reduced their Number, that had it not been for the great

great Civility of Mrs. *Clutton* and Mr. *Corbin*, Chemists and Partners, in *Holborn*, (whose kind Assistance I thankfully acknowledge in this public Manner,) it would have been in my Power to procure very few of those I shall hereafter mention.

C H A P. XXX.

TARTAR *Vitriolated.*

THE rectified Oil, or rectified Spirit of Vitriol, dropt gradually into Oil of Tartar *per deliquium*, till it causes an Ebullition, produces (by evaporating the Humidity) a white Substance called *vitriolated Tartar* †.

This dissolves readily in hot Water, and a Drop of the Solution applied on a Slip of Glass before the Microscope, begins shooting round the Edge in great Numbers of very minute and transparent *Spiculæ*, detached intirely from one another, and without any of that Basis at the Edge of the Drop

† Vitriolated Tartar is commonly an Ingredient in Powders for the Teeth, as on rubbing them with it they become white immediately : but it should be used seldom and with great Caution, washing the Teeth well with several Mouthfuls of Water afterwards ; for it whitens them by *Erosion*, and if frequently applyed will destroy their outward close and hard Coat of enamel, after which the internal and more spongy Part can last but a little while.

Drop which most other Kinds of Salts form before they shoot. These *Spiculæ* proceed and lengthen in different Directions, and cross each other at various Angles, as *a a* and *b b* shew, *Plate VI.*

Some of these *Spiculæ* are very deeply ferrated, or look rather like the Ends of bearded Darts or Arrows placed over one another, as represented at *c.*

A Kind of Star-like Figure will be found here and there amongst the *Spiculæ*, apparently compounded of the above described bearded Points, and most commonly, like them, more opake than the other Shootings: a few of these appear alone, and others are formed at the Ends of the *Spiculæ*, as at *d.* Some likewise of the *Spiculæ*, after a while begin to spread, and shoot forwards, in an irregular Manner of branching, towards the Middle of the Drop, as at *g g.* Other Figures arise at a Distance from the Edge of the Drop, with Branches dividing and subdividing more regularly than the last described; (*see F.*)

During the Process, Clusters of hexagonal Planes arise in the vacant Spaces, some regular, others with unequal Sides, some perfectly transparent, others with a small Degree of Opacity, as at *e.* These last Figures, which are indeed the proper Crystallizations of the united Salts, will remain intire upon the Glass, after all the other Configurations

figurations are broken away and destroyed by the Air.

Among the *Spiculæ* shooting from the Edges there are many strait-lined Figures, whose Ends are not pointed but flat and spreading; (*see a a.*) These are chiefly owing to the Tartar; and the Permanence of the hexagonal Crystals implies that they contain a large Proportion of the Vitriol.

N. B. It frequently happens, when a Drop of this Solution heated over the Candle, is placed under the Microscope, the Steams arising from it so obscure the Object-Glass, that nothing can be seen through it, until the Glass be clear'd with a Piece of Wash Leather, or a soft Linen Cloth.

This is the Case likewise in examining several other Solutions, as has been before remarked.

C H A P. XXXI.

FLOWERS of BENJAMIN.

THE Flowers of Benjamin are Salts obtained by Sublimation from a Gum of the same Name. These Salts are so volatile, that on putting some of the Gum grossly powdered into a subliming Pot, they rise with a small Degree of Heat into a Cover placed over them; whence they are wiped out

out from time to time (with a Feather) in the Form of long slender shining transparent Bodies, and smell very fragrantly.

They dissolve readily in warm Water; and a Drop of the Solution being examined by the Microscope, will be found a very entertaining Object.--For, first of all there arise from the Edges clear colourless and sharp-pointed Crystals (*vid. Plate VI. a a.*) which passing towards the Center, spread out like beautiful minute Shrubs, each having two or three Branches, like what are seen *b b b.* These gradually enlarge and lengthen, divide and subdivide into several Arms and Shoots, in the Similitude of Trees (*vid. f*) composing all together a Representation of beautiful little Groves or Plantations. Some however continue short, and spread into a Sort of Leaves, indented somewhat like those of Dandalion, *c c.* Little Branches likewise shoot out from Points in the Middle of the Drop, as in the Picture at *g*: and sometimes very elegant Figures of another Kind are formed in some Part of the Drop, composed of Branches rising (on a new Basis) from one another, all arched alike with an equal Curvature, and having the convex Side of each Curve adorned with many little Shootings, at equal Distances and of equal Lengths, none of which appear on the concave Side of the Curves. All this is shewn at *e.*

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These

These wonderful Configurations decay immediately after the Fluid evaporates.

N. B. When a Solution of this Salt has been made some Days, much of it will be precipitated, and appear in Crystals at the Bottom of the Phial: and if you intend then to examine it by the Microscope, 'twill be proper first to hold the Phial to the Fire, or place it in hot Water, till the Crystals become again dissolved and taken up into the Fluid. And most other Solutions should be treated in the same Manner, if they have been long made and their Salts appear precipitated: but after being thus heated they should be allowed a few Minutes to settle, otherwise the Fluid will appear turbid and unpleasant before the Glass, and the Configurations will not proceed so well.

C H A P. XXXII.

Salt of CAMOMILE.

WHEN a Solution of this Salt is examined, if much Heat be given to the Drop, the saline Particles will chiefly dispose themselves at the Sides thereof, in such Figures as are shewn *a a*, *b b*; but with a lesser degree of Heat they will form more within the Drop, in a wonderful Variety of hexangular Planes, many of which are extremely

tremely thin, flat, and transparent, (*vid. c c*, and other Figures in the Plate.) Some however have a considerable Solidity, as the Drawing also represents. The above Figures soon dissolve and break away, and towards the End of the Process several Crystals appear with square Bases, in the Form exactly of those of Sea-salt, *vid. d*, and these are more permanent than the others were.

The Taste of this Infusion is salt at first, soon after very acrid.

C H A P. XXXIII.

Salt of CORAL.

THIS Salt begins shooting from the Sides, as at *a a*, (*Plate VI.*) and proceeds, forming Bodies some of whose Parts are opake and others transparent, of a darkish brown Colour, with Channels or Hollows running from Top to Bottom, as represented *b b*. There are likewise other of the same Figures, opake at Bottom, but transparent at their Tops, and having none of the same Channels, in the manner shewn *c c*.

In some places of the Drop the same Kind of little Hillocks are seen, adorned with

surprising Configurations most exceedingly minute and delicate, bearing the Resemblance of some Species of the smallest and most elegant Sea Mosses. It is impossible to express the Beauty of these Figures, which equal any of the finest *Mocha* Stones : But an Attempt to give some Idea of them will be found *d d d*.

After the above Appearances are completed, and the Process seems all over, there frequently presents a new and unexpected Radiation of fine Lines, at equal Distances from each other, and arising as it were from a certain Point, in a very regular Order and Delineation, the Lines shortening gradually on either side, so as to compose all together a semicircular Figure, like that at *e*. I have found no regular Crystals of this Salt, nor does it usually give any Figures at all towards the Middle of the Drop.

The Solution I made use of, after standing in a Phial two or three Weeks, had a Crust over the Surface, which taken out and examined by the Microscope appeared to be a Congeries of minute Branches, in Shape exceedingly like some kinds of Coral.

C H A P. XXXIV.

Salt of BAUM, or BAULM.

THE first Shootings from the Edges of the Drop, when a Solution of this Salt is examined by the Microscope, very much resemble Leaves, *vid. Plate VI. a*, on the left Side of the Picture. But these very soon enlarge and lengthen as at *a* on the Top of the Drawing; or else like those at *a* on the right Side, which not only lengthen but swell at their Extremities, till they either divide into two or more Branches, after the Manner shewn at *d* and elsewhere in the Drop; or seeming to burst or split at their Tops, push forth Bundles of fine Hair-like Filaments, and compose such Figures with brushy Heads as are represented at *c*: which indeed are extremely pretty. Some detached Leaves are usually formed in the Middle, together with such figur'd Crystals as are there shewn, amongst which a few bear the Appearance of those of common Salt.

When the watery Part seems nearly exhale'd, all the forementioned Figures decay and break away, except the Crystals, which remain fixt: and if a full Drop has been employed, and a considerable Degree of

Heat applied, some curious Configurations present themselves upon the Glass, consisting of short strait Lines, so disposed as to form hexangular Figures, with delicate little Branchings therefrom, *vid. e e.*

This Salt is a very curious Subject for Examination.

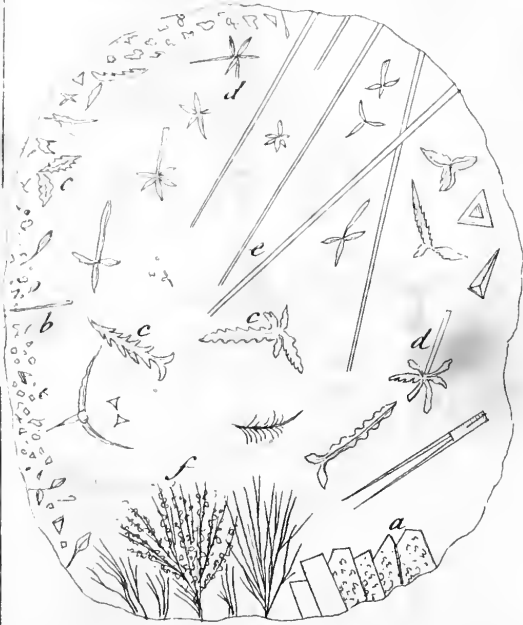
C H A P. XXXV.

Salt of FENNEL,

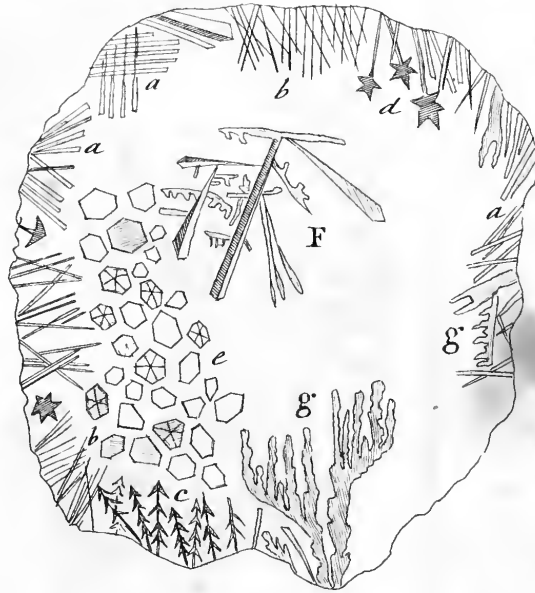
THE general Appearance which a Drop of the Solution of this Salt affords when examined by the Microscope, may be seen *Plate VII.*

After the Drop has been gently heated, innumerable *Spiculæ* rise about its Edges, extremely slender and close to one another; and amongst these, as well as farther within the Drop, many Bodies may be observed pretty regularly tapering from the Middle towards each End, somewhat like the Figure of a Rolling-Pin, *vid. a a.*—More in the Middle of the Drop are formed Crystals oddly shaped, such as *b b*; and likewise others ending pointed like a Wedge. Some again are divided, as *c*; and here and there a Crystal of marine or common Salt is found, sometimes in its usual Figure, and
some.

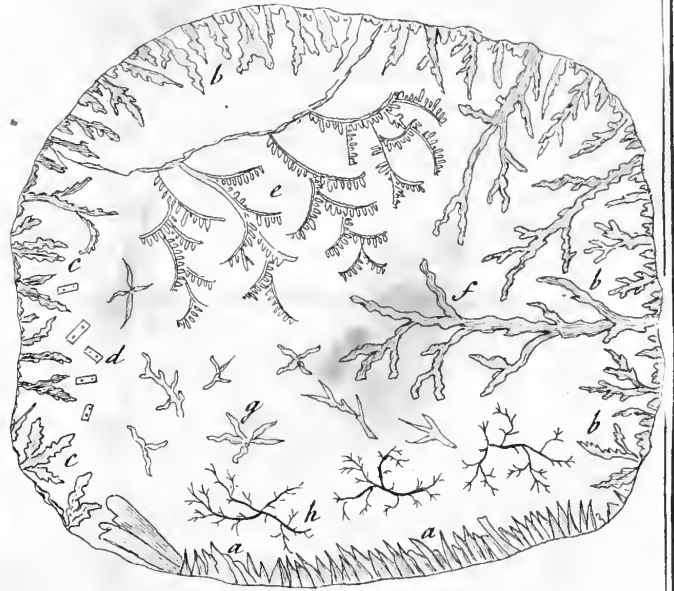
Salt of Tartar.



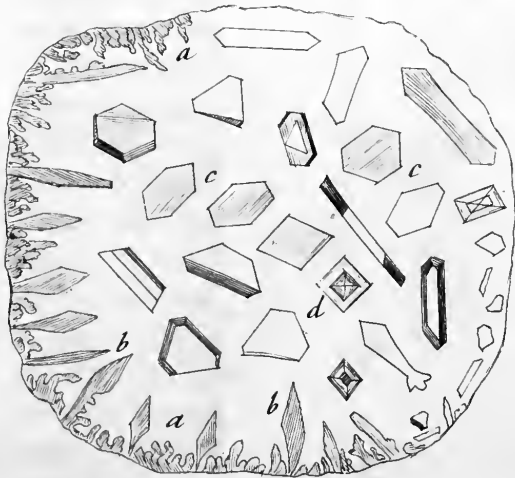
Tartar vitriolated.



Flowers of Benjamin. PL.VI. p. 166.



Salt of Camomile.

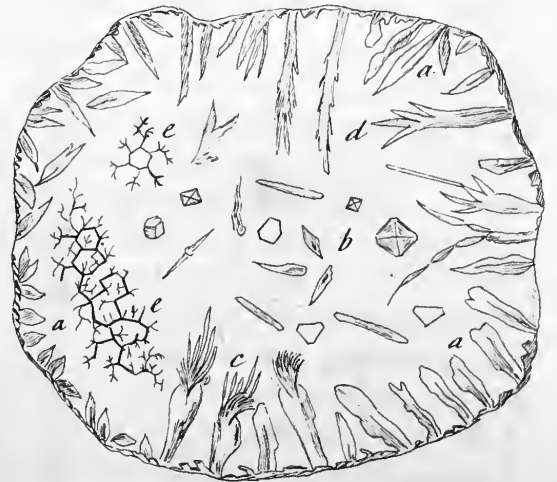


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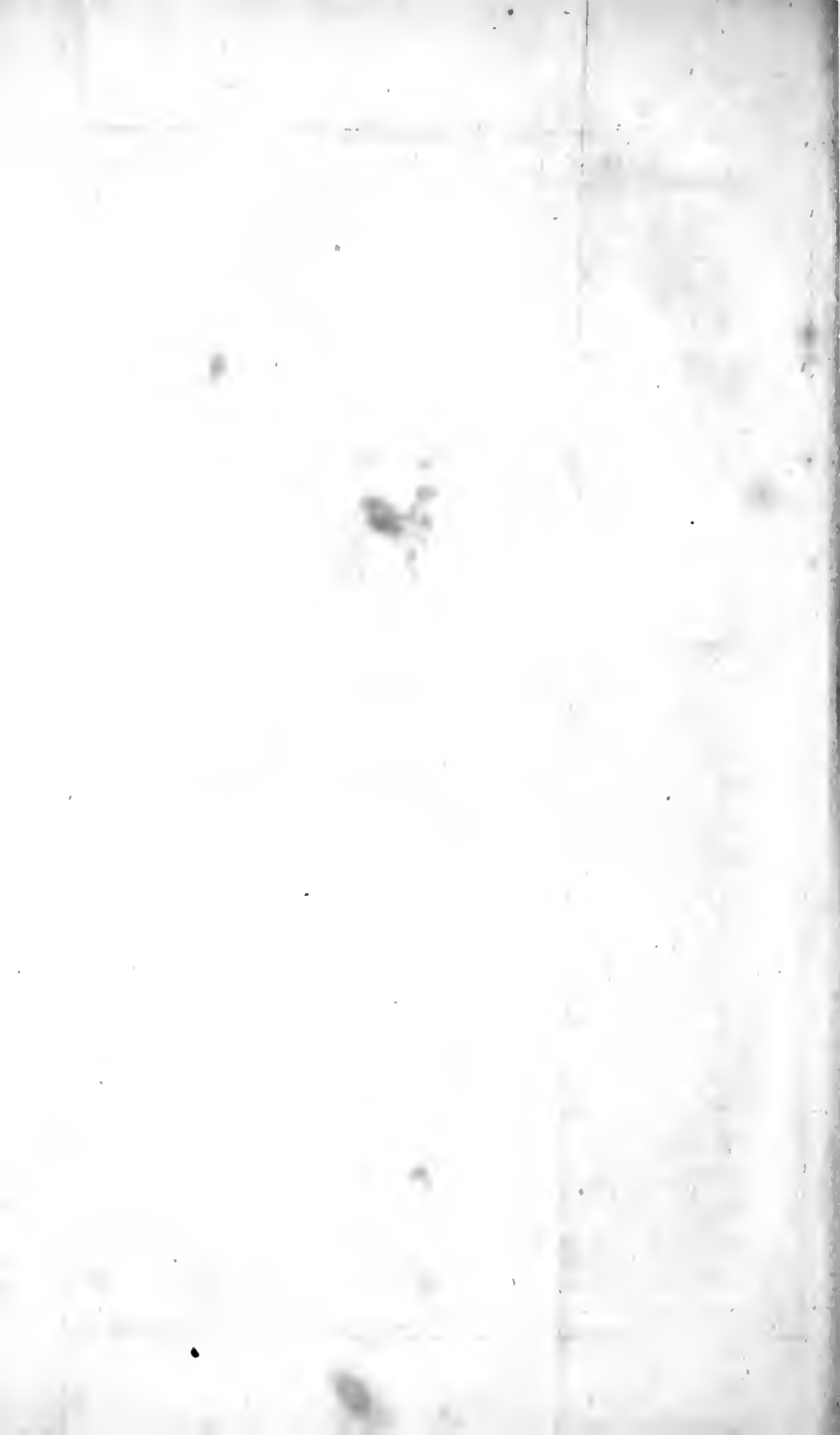
Salt of Coral.



Salt of Baum.



J. Mynde sc.



sometimes having an Opening at each Corner of the Base, as if the Angles had been artfully taken out. These Differences will be understood by examining the Figures *d d*.

The Air puts an End to these Forms soon after they are produced.

C H A P. XXXVI.

Salt of BUCKTHORN.

THIS Salt shoots from the Edges of the Drop many sharp pointed *Spiculae*, at little Distances from each other; after which the several Figures in the Drawing (*Plate VII.*) form themselves under the Observer's Eye; some are hexangular Planes, somewhat opake, and appear with a considerable Degree of Thickness in proportion to their Size, as *b*; whilst others of the same hexangular Planes are exceedingly transparent, and have no visible Depth. Parallelograms are dispersed here and there, and some Rhombi: Indeed the hexangular Figures before mentioned seem like Rhombi cut off at each End. There appear a few of the Figures *c* and *d*, and also of the other several Forms represented in the Picture.

A Syrup made from the Berries of this Shrub is an useful Purgative in Compositions; but extremely nauseous, and somewhat too churlish given alone, unless for Persons of very robust Constitutions.

C H A P. XXXVII.

Salt of the BERBERRY.

THE Heat necessary to put this Salt in Action must be very small, but brisk; otherwise it will harden into a transparent Glue, without producing any Figures; the Reason of which probably is, that being of a viscous Nature, when more Heat is given than is absolutely necessary to put the Particles of the Salt in motion, the watery Parts evaporating, leave this viscous Juice so strong, that the Crystals are entangled, and cannot force their Way through it: but are prevented from acting as they do when the watery Parts remain, and the Fluid is thereby rendered less dense.

The Figures it produces seem all to derive their Origin from *Spiculæ*, which protrude and expand themselves in the manner to be described below. Most of these *Spiculæ* are thickest in the Middle, tapering to sharp Points at each Extremity, and are
 very

very transparent; but others of them terminate more bluntly, and have their Ends opake, whilst their middle Parts only are transparent, as at *a* Plate VII. Sometimes these pointed Bodies are so disposed as seemingly to issue from one central Point, and form such a sort of Star-like or Spur-like Figure as *b* at the Top of the Drawing; or else a Figure somewhat different, resembling *b* in the Middle thereof.

But the most remarkable of all the Figures it produces are owing to the lengthening out of certain of the *Spiculæ*, whilst they expand at the same time, and push out again other *Spiculæ* from their Sides, which likewise expand themselves into very pretty transparent Forms, not unlike the Leaves of some Plants, tho' bearing no Similitude to those of the *Berberry*; an Instance of this is shewn at *d*. Others of the same original *Spiculæ* shoot not so far towards the Middle of the Drop, but divide and expand themselves laterally, spreading out into a broader Kind of Leaf-like Figures, *vid. c c c*.

Among the detached Crystals in the Drop there are many of a pentagonal Form, and somewhat more opake than the rest, terminating at one End with an obtuse Angle. They are not marked with any Letter in the Drawing, but will easily be distinguished in looking over it. ---I do not remember this Figure in any other Salt.

The

The young green Leaves of the *Berberry* Tree held in a Sieve over the Steam of boiling hot Water, rolled up between the Fingers, and dryed carefully in an Oven not over hot, may easily be mistaken for a good Bohea Tea; resembling it much in Appearance, and making a Liquor extremely like it both in Taste and Colour. --- This I have myself experienced.

C H A P. XXXVIII.

Salt of CUCUMBER.

THE first Shootings of this Salt are for the most part Parallelipipids, radiating from a kind of indetermined Center, as at *a*, *Plate VII.* Some single ones protrude themselves forwards, widening at the Extremity, and forming Figures like those at *b*. Some curvilinear Forms shoot also from the Sides, with flat Terminations, as at *c*; and others ending with sharp Points, as *d*. A few hexagonal plane Crystals, as also some Shuttle-figured *Spiculæ* arise towards the Middle of the Drop, both which are shewn at *e*.

I know not any Salt whose Shootings are so extremely pellucid as those we are now describing: For notwithstanding they have

a considerable degree of Thickness, they appear more transparent than the clearest Glass, and would almost evade the Sight, were it not for the faint Shadows cast by means of that Thickness.

Towards the End of the Operation the empty Spaces are filled up with Shootings from some of the most detached Parallelograms, which protrude themselves forwards, dividing and subdividing as at *f*, and that sometimes to such a Degree of Thinness and Slendernefs as to have the Termination of their Extremities lost to the Eye by reason of their exquisite Transparency; this may be conceived by considering the Figure *g*.

C H A P. XXXIX.

Salt of PERUVIAN BARK.

THE few Shootings which this Salt produces at the Edge of the Drop are of no regular Figure, but resemble those at *a*, *Plate VII*. The whole Area of the Drop becomes quickly filled with great Numbers of Rhombi, of different Sizes, extremely thin and transparent, *vid. b*. Some of these enlarge greatly, and acquire a considerable Thickness, forming themselves into Solids of many Sides, as *c c*. Near the
Con-

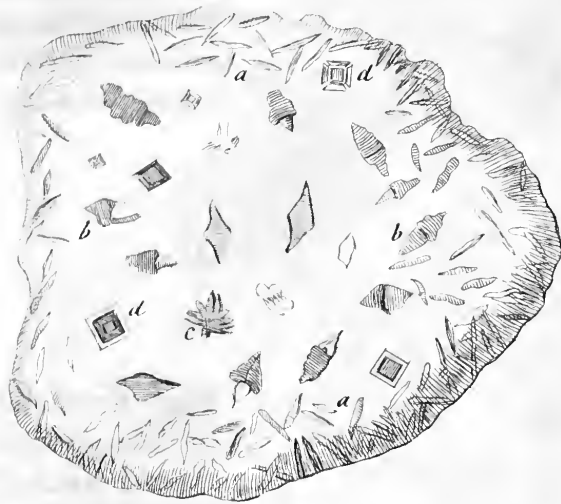
Conclusion some Crystals of Sea-salt are formed, as *d d*; and likewise a few odd triangular Figures, such as are delineated at *e*: These and the Sea-salt remain, but all the other Figures break away and soon become destroyed by the Air.

C H A P. XL.

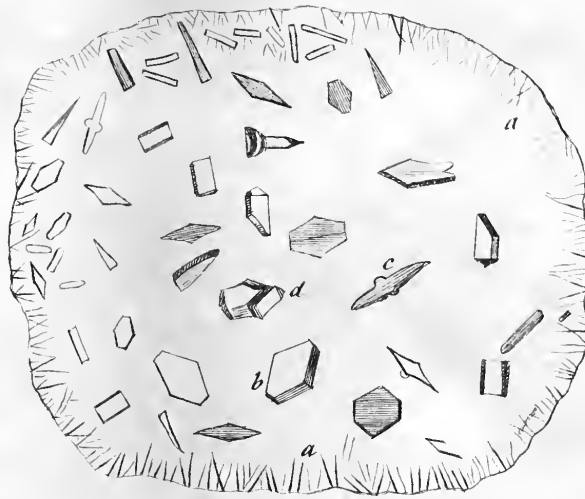
Salt of LIQUORICE.

THIS Salt begins shooting from the Edge with a Sort of Rhombic *Spiculae*, as at *a*, *Plate VII.* Some four-branched Figures like those of the Vitriols do here sometimes arise, but moulder away before their Ramifications are compleated, leaving their Stamina in the Manner represented *bb*. The Middle of the Drop is usually overspread with great Numbers of Parallelograms, some exceedingly transparent, being mere Planes; having sometimes one, sometimes more of the Angles canted, in such sort as to produce pentagonal, hexagonal, &c. Figures. Others have much Thickness, and form Parallelipipids, Prisms, &c. as at *c*. Some of the plane Figures now and then protrude an irregular kind of shooting, appearing very odd and pretty, *vid. d*.

Salt of Fennel.



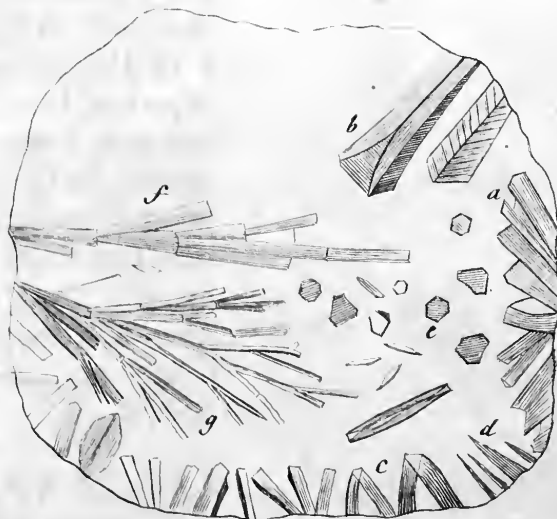
Salt of Buckthorn.



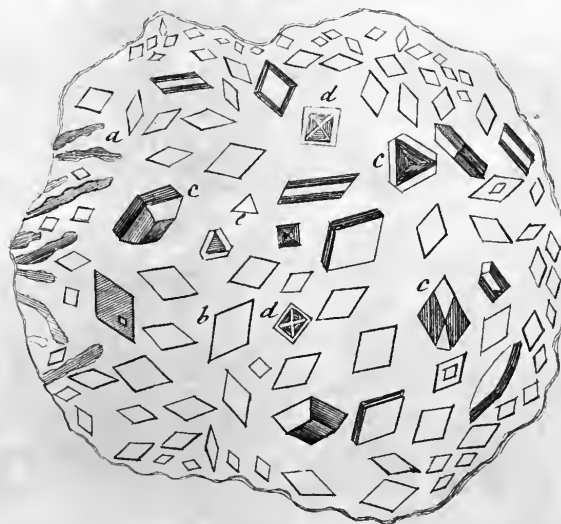
Salt of Berberries.



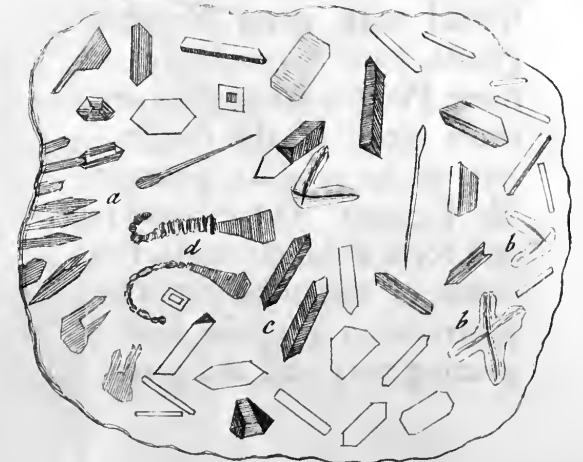
Salt of Cucumber.



Salt of Jesuit's Bark.



Salt of Liquorice.



In giving a small Degree of Heat to a
 Solution of this Salt, Figures will be
 produced from the Edges of the Drop, at
 first large, & afterwards from one another
 running on in a straight Direction, and becoming
 gradually larger and more clubbed at the
 End towards the Center of the Drop, but
 terminating in sharp Points at the End that
 is near the Edge; which is a Singularity
 peculiar to this Salt.—These Figures are cu-
 riously jagged or indented on every Side from
 End to End, and Plate VII. & A. Some
 few hours, or amongst them from out from
 their sides others of the same Kind, and
 those again other still smaller ones; but
 both in the primary and secondary Branch-
 ings the Points appear always in the same
 sides as the two Constitutions & may
 term to them.

In the Middle Part of the Drop, and
 however these are various, & sorts of re-
 gular Crystals are formed, differing each from
 each in size and shape. The larger
 are more solid, and seem to be Tetrahedra
 with uppermost Angle and the Edges
 and of these some are rectangular and
 others linear. Their Production is
 very

C H A P. XLI.

Salt of BUTCHER'S-BROOM.

ON giving a small Degree of Heat to a Solution of this Salt, Figures will be produced from the Edges of the Drop, at pretty large Distances from one another, running on in a strait Direction, and becoming gradually larger and more clubbed at the End towards the Center of the Drop, but terminating in sharp Points at the End that is next the Edge : which is a Singularity peculiar to this Salt.—These Figures are curiously jagged or indented on every Side from End to End, *vid. Plate VIII. b b.* Some few however amongst them shoot out from their Sides others of the same Kind, and those again other still smaller ones ; but both in the primary and secondary Branchings the Shoots appear always on the same Side, as the two Configurations *d d* may serve to shew.

In the Middle Part of the Drop, and wherever there are Vacancies, two Sorts of regular Crystals are formed, differing each from other both in Size and Shape. The larger Kind are solid, and seem to be Tetrahedra having their uppermost Angle and the Edges cut off, and of these some are rectilinear and others curvilinear. Their Production is a
 very

very entertaining Sight : for amidst a violent Agitation in the Fluid, numberless Atoms being seen hurried in all Directions, they rise on a sudden directly upwards from the Bottom, in the same Shape exactly as just now described, but so minute as only to be discernable by the first Magnifier, and then they increase in Bigness every Instant, under the Eye, till they appear as large as in the Picture; where at *c c* and in the Middle of the Drop several of them are shewn.--The other Sort of Crystals are very minute, being when viewed through the third Magnifier not larger than Carraway Seeds; they are mostly Rhombs or Rhomboids, some of which have the two opposite acute Angles cut off; there are besides some Squares and Parallelograms, *see a a.*

After every thing seems over, and all we have been mentioning begins to break away, it frequently comes to pass, that the patient Observer is presented with some most elegant Configurations, composed of many long Lines, perfectly strait and parallel to each other; every second or third whereof has at one End a solid Crystal shaped like the Head of a Spear or Javelin. All the Lines have also on one and the same Side Numbers of short Lines, issuing out at right Angles, and at pretty equal Distances, to about half as far as the long Lines are separated from one another. The long Lines in general

neral are bounded at their other End by a single Line, or Base, that makes a right Angle to them all : a little Variation is however produced, by here and there a shorter Line that runs parallel to this Base.---The above Description will be understood by considering the Configurations *e e*.

C H A P. XLII.

Salt of WORMWOOD.

THE first Shootings of this Salt from the Edges of the Drop appear of a considerable Thickness in Proportion to their Length : their Sides are deeply and sharply jagged or indented, being made up of many somewhat obtuse Angles; and their Ends are pointed with Angles of the like Kind. What I now describe are the single Shoots at *a*, *Plate VIII*. But other Shoots frequently branch out from these original ones, and they again send forth others, making all together a very pretty Appearance, *vid. b b*.---These last Configurations in their Figure and Disposition bear a near Resemblance to those of *Butcher's Broom*, shewn at *d d*: but are larger and more deeply indented.

The Crystals of this Salt are very different from one another, consisting of Squares, Rhombi, Parallelograms, equilateral Hexagons,

gons, some of the Figures at *cc* in the *Butcher's Broom*, a Sort of Shuttle-like Forms, and several irregular Bodies ; all of which will be best conceived by a view of them at *c*.

A small Degree of Heat given to the Drop produces more of the Configurations, a greater Heat more of the Crystals, many of which are at first triangular, but soon lose that Shape : and indeed the whole is very speedily destroyed by the Air. — This and the Subject immediately preceding exhibit no Crystals of marine or common Salt.

C H A P. XLIII.

Salt of TOBACCO.

IF a moderate Degree of Heat be given to a Solution of this Salt, its first Shootings will be from the Edges of the Drop, in slender tapering Figures ending with very sharp Points, but at considerable Distances from one another, and consequently not extremely numerous : along with these are likewise formed other Figures nearly of the same Kind, but intirely detached and farther within the Drop, and contrary to the former, in the Circumstance of having their thicker Ends towards the Center of the Drop and the sharper pointing towards its Edge. They are compleat Figures and resemble Needles, or rather that Sort of Nail called a Brad,

Bråd, which has its Head or larger End flat. Both these are shewn at *a*, Plate VIII.

When a little more Heat has been given, other *Spiculæ* are produced from the Edge, whose Ends spread on either Side and then terminate in a Point : and which have all along their Sides triangular pointed Crystals, not opposite to one another, but placed alternately, so as to represent a *Zigzag* with a Line drawn through its middle, *vid. b.*---The regular Crystals of this Salt are produced in the middle of the Drop, being either Hexagons or Rhombi, as at *c*.

When the Moisture is nearly exhæled there are sometimes seen to shoot from, or rather under the *Spiculæ*, upon the Plane of the Glass, a Representation of Leaves, very small at their first Appearance, but increasing gradually to what is shewn at *d.*---These I have seen but twice.

A violent Agitation may be discovered in the Fluid by the first Magnifier, during the whole Process, but chiefly at the Beginning, and extremely minute Crystals rising from the Bottom.

Oil of Tobacco is a strong Poison to many Animals : 'tis said a Thread wetted therewith, and drawn by a Needle through the Skin on the Back either of an Eel or Viper will make it die immediately. This I have never tried.

C H A P. XLIV.

Salt of CARDUUS.

THE Crystals of this Salt (for it shoots out no Configurations) are of different Sizes and Figures dispersed every where about the Drop. Those near the Edges are very minute transparent Parallelograms, appearing in great Numbers, as *a a*, *Plate VIII*. In the Middle arise larger Crystals, shaped exactly like those of marine Salt, *b b*. There are also much larger crystalline Bodies, formed here and there, having a considerable Thickness and Solidity, and consisting of Hexagonal and Rhomboidal Planes, *vid. c c*. It produces likewise some odd figured Bodies, which may be seen at *d d*.

C H A P. XLV.

Salt of LAVENDER.

NO Configurations are produced by this Salt and the last, that seemingly push from the Edges of the Drop, as in most of the preceding Kinds; but many regular Crystals are formed in every Part of it, after a moderate Degree of Heat has been given to it. These Crystals are of various Figures,

viz.

viz. plain Rhomboids, having one or more of their Angles very much elongated, (so as to be sometimes twice or thrice the Length of the Rhomboids from which they issue,) Rhombi, Squares, Parallelipipidons, and Hexagons with unequal Sides, or rather equilateral Triangles with their Angles cut off. In short, the Figures of this Salt will much better be comprehended by applying to the Picture, *Plate VIII.* than by any Description can be written.

C H A P. XLVI.

Salt of MUGWORT.

AT the Beginning many fine *Spiculæ*, of different Sizes, appear at and about the Sides of the Drop, along with other slender Bodies somewhat swelling in the Middle, but sharply pointed at each End, *vid. a a, Plate VIII.* Triangular solid Crystals, and various other Figures, are also formed here and there as represented in the Picture. But the most remarkable Part of this Subject, is a very elegant Sort of Configuration towards the Middle of the Drop, as at *b*; and likewise Shootings of the same Kind from its Edge, that resemble the Branches of some Plant, rising single, with Leaves regularly disposed

disposed on both Sides of each Stem, as shewn by the other *b.*---In the Middle of the Drop at *c* are Figures of another Form which are very singular and pretty. These all break away and become confused very soon after they are formed.

C H A P. XLVII.

Salt of HARTSHORN.

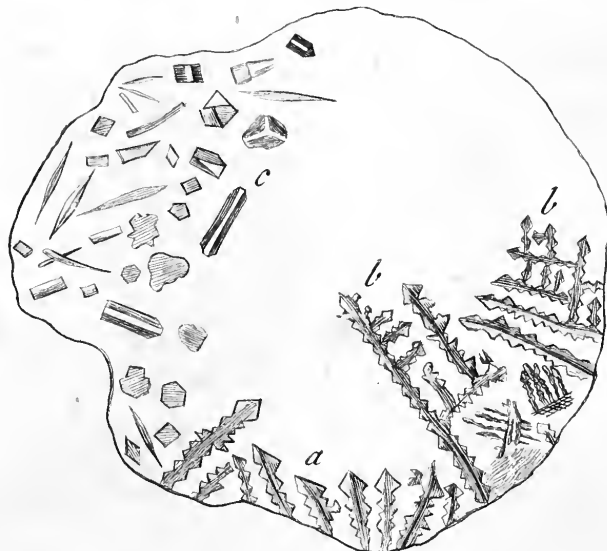
ON the Application of a very small Degree of Heat, Salt of Hartshorn shoots near the Edges of the Drop, into solid Figures somewhat resembling Razors or Lancets where the Blade turns into the Handle by a Clasp, as at *d*, *Plate IX.* This Appearance is however wholly owing to the Junction of a smaller and larger Body at their smaller Ends, in either a right or an acute Angle, as will be evident on considering some of these Bodies that appear single.

The Configurations of this Salt are produced with great Velocity, and are Figures somewhat opaque, shooting from the Edges of the Drop, on both Sides a main Stem, and with a kind of Regularity, rugged Branches like those of some Sort of Coral, *vid. a a.* But sometimes instead of Branches on both Sides the main Stem, sharp *Spiculæ*, some plain and others jagged, are protruded

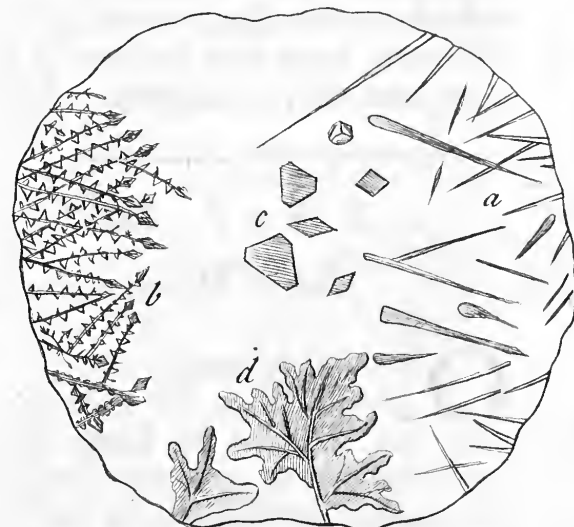
Salt of Butcher's Broom .



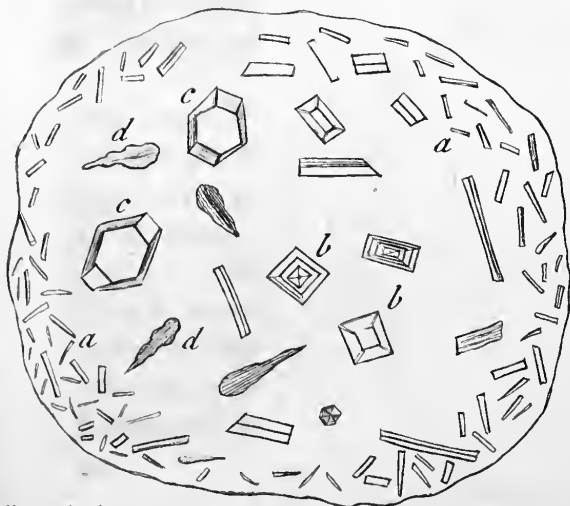
Salt of Wormwood .



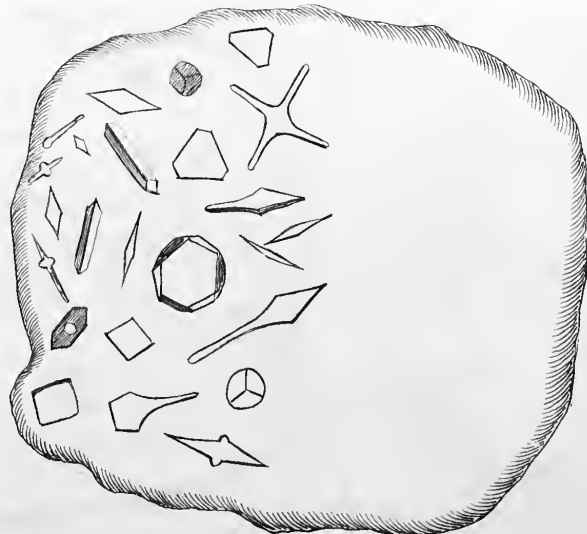
Salt of Tobacco .



Salt of Thistle.



Salt of Lavender.



Salt of Mugwort .



to a considerable depth on one Side only, as at *b*.

As the Fluid exhales, and the Attraction of the Particles becomes more strong, some one of the branching Figures generally extends to a great Length, producing on one Side Shoots that are rugged and irregular like those in the smaller Figures at *a a*, and on the other Side a curious regular and delicate Sort of Branches, resembling those of some Plant, with elegant small Leaves in the Manner shewn at *c*.

C H A P. XLVIII.

Salt of URINE.

A Solution of this Salt shoots from the Edges of the Drop long Parallelograms in the Manner of Nitre; but with this Difference, that Nitre produces solid hexagonal Pillars, cut off obliquely at their Ends, in the Figure of a Chissel; whereas these are only plain superficial Parallelograms, whose Ends are flat, as *a a*, *Plate IX*. But in other Places along the Sides of the Drop solid Angles are formed, that are seemingly the Rudiments of common Salt, (*vid. b.*) though neither this nor Salt of Hartshorn afford any regular Crystals of common Salt.

Some of the Parallelograms increase much in Size, and spread themselves in the Middle, so as to change their first Figure, and become three or four times bigger than the rest : and these have a dividing Line that runs through their whole Length from End to End, whence issue other short Lines, at small Distances, opposite to one another, all pointing with the same Degree of Obliquity towards the Base, as may be seen at *c c*.

Among these enlarged Figures some few shoot still forward and tapering towards a Point; but before they form one, swell again, and begin as it were a-new : and thus they proceed several times before their compleat Figure is finished, which is at last a kind of long sharp-pointed Body composed of more or fewer Joints as at *d d*.

After the whole Process seems at an End, many small Branches form themselves on the Surface of the Glass, as in the preceding Salt, (*see the Picture,*) though their Figure is not just the same. — All the above described appear when a very moderate Degree of Heat is given, and the Drop is applied to the Microscope as soon as any of the Salts crystalized are seen white about the Rim. But the Figures 1, 2, 3, 4, 5, 6, are the regular solid Crystals of this Salt, when it is let dissolve in the Air, and no Heat at all is given.

C H A P. XLIX.

Salt of Millepedes, or Wood-Lice.

THIS Salt shoots from the Edges in a Manner very beautiful, and different from any other Kind yet observed. It begins by issuing from the extreme Edge of the Drop in many Lines parallel to one another, but in a very oblique Direction to the Line that borders the Drop ; and other parallel Lines are produced from these, in an Angle somewhat more than right to them, the Angles of which are not sharp but rounded, *see a c d, Plate IX.* Many transparent Parallelograms of various Length and Size are formed by these Lines, some whereof afterwards shoot forwards into long Spikes which spread at the Sides with irregular Edges, as at *d d*. In the mean while other short Lines proceed outwards from the very Edge of the Drop, in a Direction quite contrary to those we spoke of first, making the Border of the Drop appear very prettily ferrated or fringed, as may be seen at the Bottom of the Configurations *a c d*. Another Sort of regular Figures are likewise produced from the Sides of the Drop, in the Manner of those *b b*. When the Operation is nearly ended, there arise abundance of long *Spiculæ* that range themselves somewhat in the Form of

Plants, filling up most of the vacant Places in the Drop as the Picture shews. This Salt has but one Sort of regular Crystals, which is hexagonal, and appears as at *e*.

C H A P. L.

R H E U M.

WHEN People get what they call a running Cold, it is not unusual for a thin clear Humour to be discharged through the Nostrils, in so considerable Quantity as to wet several Handkerchiefs, and even to fall from the Nose in Drops, if not prevented by frequently wiping it away. This Humour is what I mean by *Rheum*.

Being myself very subject to this Disorder, which is commonly preceded by a Sensation of Fulness and Rigidity in the Muscles of the Head and Face, and attended with much Heat, Redness and Soreness of the Nostrils and Parts immediately adjoining, during the Discharge, (which continues commonly three Days, at the End whereof it begins to thicken and become less acrid:) I was desirous to know whence this limpid Humour could produce so much Irritation and Uneasiness; and as a very little Consideration made me suppose it must be owing to its being loaded with pungent Salts of some sort

or

or other, I took the first Opportunity of examining it by the Microscope, and had the Pleasure then, and many times since, to find my Conjecture confirmed by undeniable Demonstration.

For this *Rheum* is so saturated with Salts, that a Drop on Slip of a Glass will soon shoot in a very beautiful and surprizing Manner, either with or without Heat: but if heated to about the Warmth of Blood, and then placed under the Eye, many lucid Spots or rather Points will be seen rising, and increasing gradually, till their Form shews itself to be quadrangular, with two transparent Diagonals crossing one another, see *a* and *dd*, Plate IX. These Diagonals shoot soon after far beyond the Square, protruding other Lines, at right Angles, from their Sides; (*vid. cc.*) which other Lines produce still smaller ones from their Sides also, in the Order of the first; and thus they go on to form Configurations, whose Elegance of Beauty nothing but seeing them can give an adequate Idea of: tho' till the Reader can himself make the Experiment, a Representation of their general Figure is shewn *b b*, and in other Places of the Drop: where great Numbers appear, in their several Gradations, and after their usual Manner, filling up almost the whole Space.

The fine Branchings in a little while break away, but the central Squares remain like
dd,

d. d.—Some Figures at their first Beginning rise in the Shape of Crosses, which Appearance is owing to the Shootings from the Corners of the little Squares, before they are large enough to be visible even by the deepest Magnifiers. The Number of main Branches in each Configuration is most commonly four, but some are found with five or more: the Branches likewise are sometimes curved; but these two Cases I take to be rather accidental than natural.

When a Drop of Rheum is set to crystallize without any Heat, instead of branched Configurations over the whole Area, as in the above Description, such are formed only in the Middle; but about the Edges Plant-like Figures are produced, shooting several Stems from one Point, and resembling a Kind of Sea-Moss, *vid. E.* Branchings somewhat of this Kind are shewn in Salt of Hartshorn.

These Experiments shew, that upon taking Cold the Humours become overcharged with Salts: how they get there, and by what Means they may be discharged, is a Matter well worth Enquiry; but such Disquisitions must be left to the Gentlemen whose immediate Profession it is to study the various Disorders of the human Body and their Cure. I may however presume to say, that as all Solutions of Salt become gradually weaker, and may be rendered quite insipid by the
Affusion

Affusion of a watry Fluid; therefore, in Cases of this Nature, the frequent drinking of warm Gruels, Teas, and such small watry Liquors, must in like Manner gradually dilute, separate, and disperse the acrid Salts, and be probably the most ready Means of carrying them off either by Urine or Perspiration.

Quere. May we suppose these Salts to have been absorbed from the external Air at the Time of catching Cold *, or to have existed previously in the Body, tho' sheathed and harmless till let loose, put in Motion and rendered acrid by the retained Matter of Perspiration : as seems to be the case in most of the animal Juices when tending to Putrifaction ?

* Mr. Freke says, in his *Essay on the Art of Healing*, where he speaks of taking Cold; " tho' every one knows that Colds proceed from receiving the Air into our Bodies improperly, yet few consider the State of the Air, as abounding at one Time with all the means of restoring Health to us and all the rest of the Creation, and at another as containing in it the Causes of Plagues, Pestilence and Famine, by its occasioning Death to Cattle, and Blights to all the Fruits of the Earth. " Pag. 147, 148.

C H A P. LI.

Of CAMPHIRE.

CAMPHIRE is a sort of resinous white Substance, either exuding from certain Trees in the Islands of *Borneo*, *Java*, *Japan*, and other Parts of the *East-Indies*, or intermixed with the woody Fibres in the Bodies and Roots of some Trees growing in these Countries. — It is not soluble in Water, but dissolves readily in Spirit of Wine, from which saturated therewith my Experiments have been all made.

If any Heat be given it must be very gentle, and the Microscope and Eye applied as soon as possible; for the Shootings form so quick they will otherwise escape the Sight, They radiate from a Center, either with six or four, rarely with five Branches, whose Length is nearly equal: each Branch is feather'd with fine Lines that diminish gradually to a Point, whereby the Figures have greatly the Appearance of Flakes of Snow; and the Points of some filling the Vacancies between those of others, small are the Spaces that are left uncovered. Some few single Branches are produced about the Edges of the Drop. A pretty good Representation of these very delicate Configurations may be seen in the XIth Plate. If

If no Heat at all be applied there will be more Time to examine the Configurations; nor even then will much Patience be required, for the Camphire and Spirit of Wine are both so volatile, that if the Drop be spread thin, they will soon begin to form, and quickly after they vanish quite away.

Camphire is of great Service when by any Accident too large a Dose of Opium has been taken.

C H A P. LII.

Of MANNA.

THIS sweet-tasted Salt is the Concretion of a Juice issuing from a kind of Ash Tree during the Heat of Summer: that from *Calabria* is accounted best. It easily dissolves in Water made somewhat hot, and a Drop of the Solution is a very pretty Object for the Microscope.

Its first Shootings are Radiations from Points at the very Edge of the Drop: The radiating Lines appear opaque, but extremely slender, *vid. a a a, Plate XI.* Amongst these arise many minute transparent Columns, whose Ends grow wider gradually as they extend in Length, and terminate at
last

last with some degree of Obliquity, *b b*. All the Figures round the Edges being formed in Clusters, and making but half a Circle, bear a near Resemblance to Bundles of spun Glafs.

Some few Figures radiating from a Center every way, and circumscribed by an Out-line, are produced within the Drop, in the manner shewn *d d*.

But the most surprizing and elegant Configuration is composed of many Clusters of Radiations shooting one from another over great Part of the Drop, and making all together a Figure not unlike a certain very beautiful Sea-Plant. *Vid. C*. The regular Crystals may be seen at *e*.

The Manna I examined was, I believe, genuine; but I am told a great deal is made abroad, and some in *England*, by an artful Composition of Honey, *Glauber's* Salt, and perhaps some other Ingredients. A late Writer supposes they make it abroad of Honey, Sugar, and the Juice of a Tithymal or Spurge.* It is worth observing, that in
the

* *Christoph. a Costa* says, that he saw a *fictitious Manna* sold at *Ormuz*, which was also carried into several Provinces of *Persia*, in larger Flakes and not so white as the genuine; but it was cheaper, and purged violently. And he was informed of its Composition by a certain *Brachman*, *viz.* white Starch, some true Manna, Scammony, a Kind of Seed brought from *Bengal* by the Name of *Visa*, the Powder of a Root called *Dante*, and some Sugar, mixed together with a little perfumed Water, and exposed to the Sun. — —

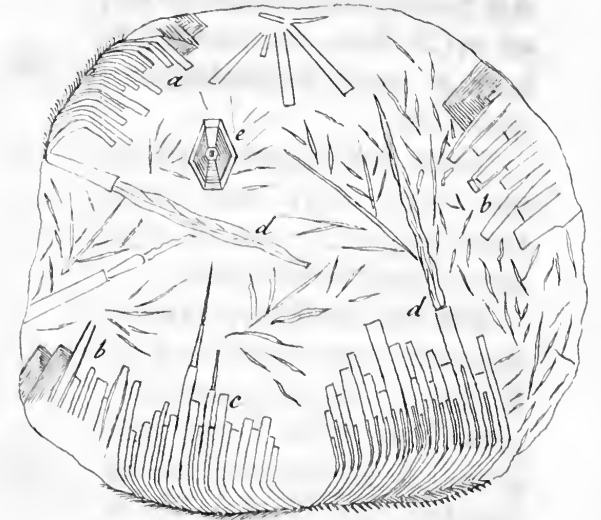
Salt of Hartshorn .



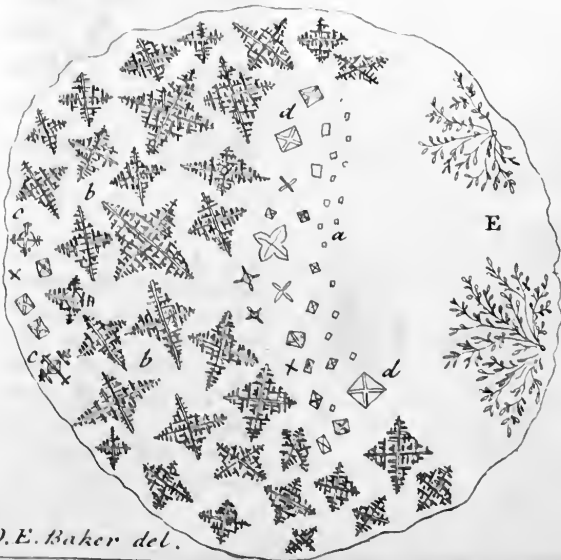
Salt of Urine .



Salt of Millepedes . Pl. IX p. 190.

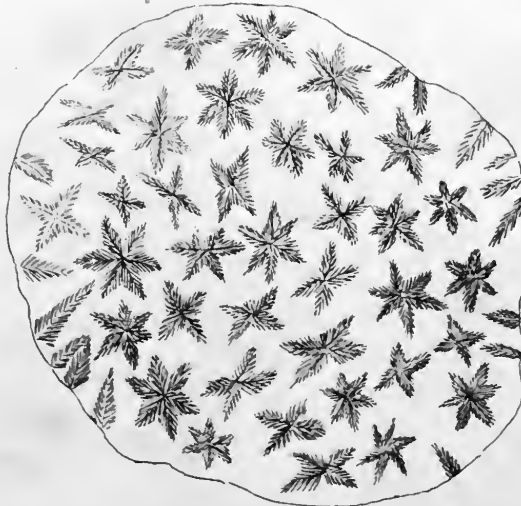


Rheum .

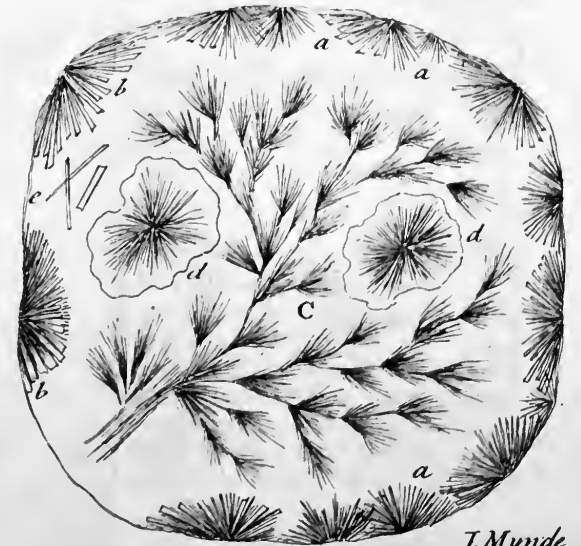


D. E. Baker del.

Camphire .



Manna .



J. Mynde sc.

the Midst of the largest Flakes of Manna little Twigs are frequently found, not thicker than Straws, round which the Manna seems to adhere as Tallow does round a Wick that is dipped therein.

N. B. I should here direct an Examination of *Sugar*, but could never find a way of bringing it to shoot or crystallize before the Microscope. All other Salts after Evaporation will shoot their Crystals in a cool Place, but *Sugar* requires a hot Stove to make it crystallize. The Figure of its Salts *candied* may be seen in *Plate XIV.* of *the Microscope made easy.*

C H A P. LIII.

Concerning the Vegetation of METALS:

AFTER what has been already shewn and described, the considerate Reader will be at no great Loss to judge of what Writers commonly call the *Vegetation of Metals*, and the *Resuscitation of Plants*, both which I shall treat of briefly.

When

Mefue likewise mentions the adulterating of *Manna* with *Sugar* and the Leaves of *Sena*: but adds, that this Fraud discovers itself by its growing soft and liquifying.

When any Metal is dissolved in a Menstruum, Multitudes of its separated and very minute Particles are suspended in the Menstruum, as are likewise the Particles of its Salt or Vitriol. In this Mixture, when set to rest, many of the salt or vitriolic Particles are brought together, after a while, by Precipitation and Attraction, carrying with them Particles of the Metal; and form Crystals, in Figures peculiar to the Metal dissolved: *viz.* *Lead* produces Cubes, *Tin* quadrilateral Pyramids, *Copper* produces oblique-angled Parallelipipids, and *Iron* rhomboidal Crystals. This is the Case of one Metal dissolved singly in a Menstruum without any Mixture; and no farther Alteration happens by keeping, than that more Crystals will form like the first, or that the first become enlarged, by the Precipitation and Attraction of more of the vitriolic Salt: Perhaps too some of the metallic Particles (if it has been over-charged) will be found at the Bottom of the Fluid, though great Part of them will always remain suspended.

But if different Metals or metallic Substances be dissolved in the same Menstruum, or in different Menstrua, and afterwards mixed together: or if other Fluids be poured into any Solution of a Metal or Mineral, the suspended metallic and vitriolic Particles, having different degrees of Attraction and Gravity, are precipitated and
 attracted

Arbor Dianæ, or, the Silver Tree. 193

attracted by one another in a Variety of complicated Directions, and unite in Configurations extremely wonderful and pretty. Some Productions of this Sort have been discovered by Accident, and called the Vegetation of Metals, and many more might undoubtedly be found, were Trials made with Mixtures of different metalline Bodies and different Menstrua. I shall give a few Examples of such metallic Configurations.

ARBOR DIANÆ, or, the Silver Tree.

Dissolve an Ounce of fine Silver in four Ounces of *Aqua Fortis*: dissolve likewise in one Ounce of *Aqua Fortis* as much Quick-silver as it will bear: mix the two Solutions in a clear Glass with a Pint of Water, stop it close, and after a Day it will begin to grow.

Or, dissolve in *Aqua Fortis* of pure Silver one Dram; put to the Solution, of distill'd Vinegar and Water each one Ounce: filter, and add one Ounce and a half of Quick-silver; mix, and shake the whole some time, in a round clear Glass Vessel, stopping the Mouth close with your Finger. Standing quiet 24 Hours it will shoot into *Branches* of various Figures.

Monf. *Homberg* tells a way of producing a *metallic Tree* much sooner, after the Preparations are got ready.—Make four Drams of fine Silver into an Amalgama

194 *Arbor Martis, or, the Iron Tree.*

without Heat, with two Drams of Quick-silver: dissolve this Amalgama in four Ounces of *Aqua Fortis*: pour the Solution into twelve *Paris* Pints (about three Gallons) of common Water; stir it well together and keep it in a Glass Vessel well stop'd. To about an Ounce of this Water, in a small clear Phial, put the Quantity of a small Pea of the common Amalgama of Gold or Silver, which should be as soft as Butter. Let the Phial stand a few Minutes, and you will see small Threads or Filaments rising perpendicularly from the little Bulb of Amalgama, and thrusting out from their Sides little *Branches* in form of a Tree. The Bulb of Amalgama will grow hard, and be like a Pellet of white Earth, but the little Tree will be of a bright Silver Colour.— The stronger the first Water is made, the sooner formed and fuller of Branches will the Tree be.

Albertus Magnus is said to have produced a metallic Tree before the King of France, while he sat at Dinner; I suppose by some such Method.

ARBOR MARTIS, *or, the Iron Tree.*

Dissolve Iron Filings in Spirit of Nitre, pour on Oil of Tartar *per deliquium*, and a sort of Branches will be formed and adhere

to

Arbor Veneris, or, the Copper Tree. 195

to the Surface of the Glass, representing
Leaves and Flowers,

ARBOR VENERIS, or, the Copper Tree.

The seeming Vegetation of Silver and Iron just before described, I give from other Writers; but this of Copper is I believe intirely a new Discovery: and I can affirm, from my own Experience, that it is extremely wonderful and pretty, and made with little Trouble.

In half an Ounce of *Aqua Fortis*, let a bright Halfpenny, or some small † Piece of clean pure Copper remain for about twelve Hours, and then take it out. Dissolve a little *Quick-silver* in as small a Quantity as you can of the same or stronger *Aqua Fortis*. The Solution will be white, and like Flour and Water; at which Instant it must be put into the first Liquor, which will immediately become of a lovely blue, and throw down something of a white Sediment, but have very little Body or Consistence. Have ready some *Salt Ammoniac* finely
O 2 powdered,

† Tho' *Aqua Fortis* acts on the Filings of Copper faster than it can on a Lump of that Metal, I have by Experience found that very small Particles of Iron rubbed from the File, and mixed with the Copper Filings, do much Prejudice to the Experiment.

As Fumes arising from the Solutions of Metals in *Aqua Fortis*, &c. are disagreeable and unwholesome, 'tis adviseable to make them in the open Air, and so placed that the Wind may blow the Fumes from you.

196 *Arbor Veneris, or, the Copper Tree.*

powdered, whereof put in a very little at a Time ; stirring it about till it dissolves, makes the Mixture of a blueish white, and gives it a Consistence like to Starch ; which Condition shews it fit for your Purpose.

File bright any small Piece of Iron, (the pointed End of a Nail about an Inch in length, or a small Nail of that length called a *Brad*, does as well as any thing) place it on the Middle of a Piece of clear Glass of two or three Inches in width: then stirring the Mixture with a Quill, let a Drop fall from the End of the Quill upon the Iron, and wet it therewith all over, (or dip the Iron in the Mixture, before you lay it on the Glass, till it appears of a Copper Colour,) add another Drop or two of the Mixture, and with your Quill spread it to equal Distances from every side of the Iron, an Inch or more, laying it so thin as to be transparent. Let it remain quiet in an horizontal Position, and in a little while you will discern with the naked Eye Ramifications of the purest Copper shooting from the Sides of the Iron, resembling the most elegant Branchings seen in *Mocha Stones*, (which may perhaps be produced by Mixtures in the Earth somewhat a-kin to these) or like some of the most minute and delicate Sea-mosses. They will grow continually larger for Hours or Days, in proportion to the Extension of the Liquor round the

the

the Iron. For the *Copper Particles* afloat in the Fluid, being first of all attracted to certain Points in the Iron, and afterwards attracting one another in an orderly Succession, arrange themselves, by the Influence and Co-operation of the Salts wherewith they are now joined, in such manner, as to compose by *juxta-position* a Resemblance of the most regular and beautiful Vegetation. And this Attraction and Formation of new Branches seems to go on, until all the *Copper Particles* in the Fluid are attracted and disposed by one another in the same wonderful Direction and Order.

Lest I should not have expressed myself with sufficient Clearness to be perfectly understood, I have given a Drawing, taken with considerable Exactness, of one of these Productions, which now lies before me, and has been growing four Days : (*see Plate the last*) this will shew the Manner of placing the Nail, and spreading the Liquor round it, and likewise what may be expected from it. The Drawing is not magnified, but the real Size of the Object, which is large enough to be seen plainly by the naked Eye.

The chief Difficulty in this Experiment arises from the great Difference in the Strength and manner of the *Aqua Fortis's* being prepared at different Shops, and even at the

the same Shop at different Times † : which is the Reason I could never exactly ascertain by Weight the just Proportion of the *Mercury* and *Salt Ammoniac* ; that depending on the Strength and Composition of the *Aqua Fortis* ; and therefore will admit of no other Rule, than observing the Colour and Consistence of the Mixture, which if not white enough wants *Mercury*, and if too thin wants *Salt Ammoniac*, or both. But as neither of these must be in Quantity to weaken much the Solution of Copper, 'tis adviseable to stir them in by a very little at a Time. As much of the Solution of *Mercury* as may amount to about $\frac{1}{10}$ part of the whole, and four or five Grains of *Salt Ammoniac* to half an Ounce of *Aqua Fortis*, is usually near the Mark. If right, after standing a little, a thick white creamy Matter rises to the Top, a white Sediment falls to the Bottom, and the Middle is a fine transparent blue Liquor. When used it must be stirred together, and employed before it separates : and when spread upon the Glass it appears of a bluish white ; which Ground is

† Some *Aqua Fortis* I bought became in dissolving Copper not of a blue but of a green Colour ; but on putting in the *Mercury* it changed to a most lovely blue, and made the best Mixture I ever had ; for it might be seen to vegetate in a Minute's Time : and produced, in a few Hours, vigorous Branches of an Inch in Length. But there is some Nicety requisite in the Management of the *Mercury* ; for the Minute it is dissolved by the *Aqua Fortis*, even before the Fermentation is quite over, it must be mixed with the Solution of Copper, or else it will concreate into a white Substance like Salt, and never mix intimately with the Copper Solution.

so fine a Contrast to the Colour of the Copper, that when the Branches are formed it looks like the finest *Mocha Stone*: and a Jeweller to whom I shewed one of these Productions told me, a Stone like that would be worth an hundred Guineas.

This Experiment seems of great Importance; serving to explain how Ramifications of a like Appearance are produced, either on the Surface or in the Fissures of *Slate, Flints, Agates, Mocha Stones, Florentine Marbles, &c.* and perhaps even in their very Substance at the Time of their Formation, by the Intermixture of saline and metalline Particles; and also how Metals, dissolved by and incorporated with the saline Juices of the Earth, are formed into *Branches* and seem to vegetate †. It was discovered, accidentally, by the very ingenious Mrs. *Colembine*, of the City of Nor-

O 4 *wich,*

† Of this Kind I suppose the *Ramifications* of Silver, Copper, and Iron to be that are met with oftentimes in Mines; either incorporated with the Stony Bed of the Metal, as in the capillary, vegetative, or arborescent *Silver Ore* from *Potosi*, or in Shootings or Branchings out from the Ores themselves: in the Manner of an *Iron Ore* described by Doctor *Woodward*, (Vol. I. Class IX. Part IV. N^o 85.) having very fine *Shoots* or *Efflorescencies*; from a perpendicular Fissure in a vastly high Mountain in *Cumberland*; where he says, great Numbers of much finer Shoots than that in his Possession, (but so brittle and tender he could not preserve them,) rose like Vegetables, with a single Stem, which parted afterwards into several Branches, of all Sizes, to the Height of near two Inches. The Stems were round, and so were the Branches; but towards the Extremities they were so jagged as to resemble common *Heath*. They were exactly of the Complexion of Iron, a dusky red with a Cast of blue.

wich, in her search after new Colours, from Copper, for painting in Miniature. The *Scarlet Dyers* use in their Business *Aqua Fortis* saturated with Tin, and make no Secret of it; but one of that Trade, who is thought to excel in the Richness of his Scarlet, prepares his *Aqua Fortis* after a Manner known only to himself. In some of this Mrs. *Colembine* dissolved Copper: and happening to leave a Piece of Iron in the Mixture, she was surprized with the Branchings from it, and shewed them to my very ingenious Friend and Correspondent Mr. *William Arderon* F. R. S. who by her Desire sent an Account thereof to me, (in *June 1751*) and with it some of the same *Aqua Fortis*; whereinto I put an Halfpenny, and let it remain four or five Days according to his Directions; in which Time the *Aqua Fortis* acquired the Consistence of Starch of a pale blue Colour; and on applying it to a Nail, in the Manner described already, it might, in a very few Minutes, be seen to shoot out Branches, that would continue growing five or six Days, according to the Extension of the Fluid; and in numberless Trials it never failed once. The Branches were evidently of a pure and finely coloured Copper, rising above the Fluid, exactly regular, and perfectly distinct and separate; as the Drawing, which was taken from a Production by the same Liquor that had been growing four Days, will shew.

This

This *Aqua Fortis*, which was very clear and pale, with a slight Teint of a pearly Colour, was supposed to be only saturated with *Tin*: but on trying *Tin* with other *Aqua Fortis*, and making Experiments with *Aqua Fortis* prepared by other *Scarlet Dyers*, we found ourselves disappointed and the Vegetation very imperfect.

Aqua Fortis bought at several Shops in *London*, corroded, or rather burnt the shavings of *Tin*, with great Fermentation, Heat and Violence; reducing them to a white Paste-like Substance, that lay at the Bottom and left the Liquor perfectly colourless: and when the Copper was afterwards put in, conduced not at all towards giving the Mixture a Consistence, or promoting the Branchings out; whereas the *Tin* in *Mrs. Coleombine's Aqua Fortis* was kept suspended, threw down no Sediment, and thickened the Mixture. But as that *Aqua Fortis* can not be got by People distant from *Norwich*, many Endeavours have been used to produce the same Effect by other Means: and we luckily found it might be done by the Method just now described. We discovered also, in making Experiments without Number on this Occasion, that different kinds of Branchings equally surprizing and beautiful may be produced by different Mixtures. *Viz.*

Aqua Fortis saturated with Copper, and applied to a Nail, will without any Addition shoot forth very pretty Branches, after standing quiet a few Hours, if a due Pro-

202 *Arbor Veneris, or, the Copper Tree.*

portion of *Nitre* be in the Composition of the *Aqua Fortis*.

A like Solution, with the Addition of *Salt Ammoniac**, will shoot sooner and stronger.

If some *Nitre* and *Alum* powdered, and in equal Quantities, be put to the same Solution of Copper, instead of *Salt Ammoniac*, Branches will be produced, of quite another Fashion and Character.

Dissolve 7 or 8 Grains of *Tin* Shavings in half an Ounce of Spirit of *Nitre* : this will be effected without great Ebullition, and the Metal be intirely suspended. Put into the Solution a clean Halfpenny, which take out after 12 Hours ; then add a few Grains of *Salt Ammoniac*, putting it in by little and little, and trying the Mixture from time to time. This shoots very well.

Aqua Fortis sent me from *Norwich*, (made there by Mr. *Finch*) shoots very well either with or without *Tin*. It dissolves *Tin* without any Precipitation, and afterwards acquires a Consistence with Copper, like that of Mrs. *Colebine*.--Five Grains of *Tin* were put into 7 Pennyweight of this *Aqua Fortis* : In less than an Hour an Halfpenny was put into the Solution ; and two Hours after, a Nail being dipped in the Mixture, (which was then as thick as Starch) and placed upon the Glass with some more of the Mixture round it, began to vegetate in five Minutes.

An
* *Salt Ammoniac* with *Aqua Fortis* makes an *Aqua Regia*.

Arbor Veneris, or, the Copper Tree. 203

An Halfpenny was put into four Penny weight of the same *Aqua Fortis*: four Hours after a Nail was dipped therein, and placed upon the Glass, and in 15 Minutes the Copper shot itself all round. *Salt Ammoniac* added to it quickens the Experiment and makes the Shootings stronger.

A Solution of Copper in *Aqua Regia* shoots out pretty Branchings of Copper, and better still if some *Salt Ammoniac* be put to it after the Copper is taken out.

Tin will dissolve and be suspended in *Aqua Regia*: it blackens the Liquor during the Ebullition, but leaves it at last clear without any Precipitation.---Dissolve 7 or 8 Grains of *Tin* in half an Ounce of *Aqua Regia*, then put in an Halfpenny, which let remain 24 Hours. This Mixture will have the Consistence of Starch, and will vegetate round the Nail; it is of a dark green Colour. 'Twill be improved by a little *Salt Ammoniac*.

I could give many other Experiments of this Nature, but the *Curious* and *Ingenious* will be able from these Hints to make Discoveries themselves of a great Variety of Branchings, by dissolving Copper in different Menstrua, and adding Mercury, Tin, Nitre, Alum, blue Vitriol (which contains *Copper*,) Corrosive Sublimate, Saccharum Saturni, Borax, &c. This may easily be done, by adding which they please to a Drop or two of the *Copper Solution* upon a Plate of Glass, and trying it with a Nail: and if they

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like

like the Effect, the same Mixture may then be made in a large Quantity and kept in a Phial to entertain them at any Time ; for all these Mixtures may be preserved in good Condition many Months*.

It may be proper to observe in general, that those Mixtures are the most agreeable which have some *Body* or *Consistence* ; and that such Consistence is given by adding a Solution of Mercury to the Copper Solution, and then putting in *Sal Ammoniac* ; or by dissolving *Tin* in the Menstruum before the Copper is put in. If the Mixture corrodes the Nail it never does well ; or if it turns green round the Sides thereof, which it will do when overcharged with *Sal Ammoniac* ; but despair not of any Nail's shooting till it has lain twelve Hours.

If you can procure *Aqua Fortis* that will dissolve and suspend *Tin*, (not burn it into a white Powder) the whole depends on leaving it of such due Strength, that it may be able to dissolve Copper enough, after it has dissolved the *Tin*, and yet not be so strong as to corrode and raise Blisters on the Nail moistened therewith, thereby discolouring the Copper and spoiling the Experiment.

On

* 'Tis best to keep all Mixtures with acid Spirits in a little Box by themselves, and in Phials (holding an Ounce at least) not more than half filled ; for some of them will ferment and stand in need of room : they should also have well fitted Glass Stopples.

On the contrary, if too much *Tin* be dissolved in the *Aqua Fortis* it becomes whitish or milky, dissolves not enough of the Copper, and is too weak for Vegetation. Disappointments will also happen if Care be not taken in proportioning the Mercury and *Sal Ammoniac*, when they are employed: and yet the certain Weight and Measure cannot be laid down, from the great Difference in *Aqua Fortis*.

The Nail or piece of Iron should be filed bright at the Time 'tis used, and its Surface made so even that it may come close to the Glass its whole Length. 'Tis best to hold the Nail in the Mixture for a Second or two, till it is of a Copper Colour, before you place it upon the Glass: your Shoots will thereby be made the stronger, as the Copper Particles floating in the small Quantity you put upon the Glass, finding the Iron already covered, will dispose themselves more into Branches. But doing this often will impoverish your Mixture by drawing the Copper out of it: and therefore 'twill be right to keep some separately for such an Use.

The *Branchings* push out to the Extremity of the Drop, and then frequently turn along the Edges, still dividing into smaller Ramifications, till at last they run into one another and become confused; or else a yellow Tinge drawn from the Iron diffuses through the Fluid and renders them obscure; but neither
of

of these happen till the Vegetation is nearly at an End, which is not till after several Hours, and in some Sorts several Days. They may however be preserved in good Condition, by preventing any farther Action of the Salts, when the Shootings are advanced to their utmost Perfection, if at that Time the Nail be taken away carefully with a pair of Nippers; then soaking up the Liquor where the Nail lay with a little Brush or Rag, dip the Glass gently into Water, and hold it there a few Seconds. Hereby the Shootings are stopped, the Branches are left upon the Glass in very good Order, and if another Glass be put over them, guarded with Slips of Cork as directed *pag.* 36, they may be kept many Years. Sometimes indeed they will turn green (that is, grow rusty) but as their Forms continue, it takes but little from their Beauty.

Tho' all these Ramifications are large enough to be seen distinctly by the naked Eye, being frequently above an Inch in length, 'tis very desirable to examine them by Glasses through the different Stages of their Progress; for the Microscope discovers on some of them the Appearance of Flowers and Fruits, and shews many curious Particulars not else to be conceived. The 4th or 5th Glass are best for these Subjects, which require no great Magnifier.

Copper cannot perhaps be brought to vegetate so strongly any way as by being dissolved in *acid Spirits* ; but having in the Course of my Experiments discovered other Means of bringing it to produce *very elegant Branchings*, tho' so small as to require being viewed with Glasses, I shall not conceal them from the Reader.

Dissolve as much of the *bluest* and *cleanest Vitriol* in warm Water as it can possibly sustain. Put a very little *Sal Ammoniac* in fine Powder upon the Glass Plate, to which add two or three Drops of the Vitriol Solution. When the *Sal Ammoniac* is dissolved, place in the Mixture upon the Glass a small *Brad* filed bright, wet it all over with the Liquor, and spread the Liquor round it, as in the foregoing Experiments : It will immediately attract the Copper in the Vitriol, and soon begin to shoot out Branches, the form of which, as the Microscope will shew, very much resembles *Heath*. ---- *Sublimate* instead of *Sal Ammoniac* causes a different Kind of Shootings. --- If the Copper Solution be overcharged with *Sal Ammoniac* or *Sublimate* it will not shoot at all, but turns yellowish round the Nail. A few Trials will settle the Proportion, which is according to the Quantity of Copper in the Vitriol. An exceeding small Drop of Spirit of Wine will raise a Fermentation with the Vitriol, but

but that being over before the Nail is applied, it makes the Shootings stronger.

The first Principle of Action in all these Experiments is the *Attraction* of Copper by Iron; but that only serves to cover the Iron with Copper Particles, in the Manner before described, *pag.* 80 and 81. The *Branchings* of every Sort are owing to the *Agency of Salts*; which Consideration may perhaps lead to Means of producing Vegetations from other Metals.

'Tis hoped the dwelling so long on these Experiments may be excused: as they are extremely pretty in themselves, and seem to open a Way towards accounting for many of the most curious Productions in Nature.

C H A P. LIV.

Of the RESUSCITATION of PLANTS.

THE Chemists tell wonderful Things of the *Resuscitation* or *Resurrection* of Plants from their Ashes; and I make no Doubt extraordinary Configurations have been produced in very strong Solutions of vegetable Salts, by the Means of Precipitation and Attraction: but I cannot help believing that Imagination has been greatly indulged, when they talk of Branches, Leaves and Flowers, *exactly resembling* those to which the Salts belong.

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The famous Physician *Quercetanus* tells a strange Story of a *Polonian* Doctor, who shewed him a dozen Glasses hermetically sealed, in each of which was a different Plant, as a Rose in one, a Tulip in another, a Clove July-Flower in a third, &c. When these Glasses were first brought to View, you saw nothing in them but a Heap of Ashes at the Bottom; but on the Application of some gentle Heat under any of them, there presently arose out of the Ashes the Idea of the Flower and Stalks belonging to those Ashes; and it would shoot up and spread abroad to the due Height and Dimensions of such a Flower, and had the perfect Colour, Shape, Magnitude, and all the other Accidents, as if it were really the Flower. But whenever the Heat was drawn from it, as the Glass and the included Air and Matter cooled by Degrees, so would this Flower sink down by little and little, till it would bury itself in its Bed of Ashes; and thus it would do as often as a moderate Heat was applyed or withdrawn. *Kircher* is said to have done the same Thing at *Rome*.

Dr. *Cox* gave an Account to the *Royal Society*, (*Philos. Transf.* N^o. 108) “ that having
“ procured a large Quantity of *Fern Ashes*,
“ from *Fern* burnt when between green and
“ dry, he extracted their Salt in the common
“ Manner with Water, and obtained several
“ Pounds of Salt, after evaporating the Wa-

“ ter; the greatest Part of which, being first
 “ dried, he exposed to the Air, that it
 “ might become an Oil *per deliquium*.
 “ The Remainder of the *Lixivium* which
 “ continued fluid, being filtered whilst
 “ warm, was of a very red Colour, deeper
 “ than florid Blood and most Clarets, and
 “ exceeding ponderous. The Colour shew-
 “ ed it abounded with sulphureous or oily
 “ Parts, and the Weight that it was highly
 “ saturated with the saline. This strong
 “ Solution being put in a capacious Glass,
 “ in five or six Weeks deposited a large
 “ Quantity of Salt, at least two Inches thick,
 “ over the Bottom of the Vessel. The
 “ lowest Part of the Salt was of a dark Co-
 “ lour, as if some Dirt or Dregs were mixt
 “ therewith, but the Surface next the Liquor
 “ was exceeding white; and there sprung
 “ out of the whole Mass of Salt, at small
 “ Distances from each other, about forty
 “ Branches, which (excepting the Colour)
 “ did most exactly resemble that Kind of
 “ *Fern* which is single like *Polipody* and not
 “ branched, sending out several Leaves on
 “ each side from one Stem. They differed
 “ in Size, but were all alike in Figure, with-
 “ out the least Variation: only some emit-
 “ ted more Leaves from the Stem than
 “ others; which is also usual in the natu-
 “ ral *Fern*. ”

Dr. Cox likewise adds, " that mixing equal
" Parts of *Sal Ammoniac* and Pot-Ashes, the
" latter of which had a very strong sul-
" phureous Smell; yet seemed to abound
" with Salt considerably alkalized; the Mix-
" ture being put into a tall Glass Body, im-
" mediately upon feeling the Heat a great
" deal of volatile Salt was sublimed, and in
" the Glass Head he observed, to his Sur-
" prize, a Forest in Perspective of *Firs*,
" *Pines*, &c. so admirably delineated, as not
" to be excelled, if imitated, by the Pencil
" of the greatest Master."

Having left a small Quantity of Compound Syrup of Balsam in a Phial, that was set by and forgot, with only a piece of Paper thrust into the Mouth of it instead of a Cork; when it came to hand two or three Months after, I found all the watery Part evaporated and the Sugar crystalized at Bottom: and, what surprized me very agreeably, the saline Particles of the Gums and Balsams, of which it was composed, had shot themselves almost intirely round the Inside of the Glass Phial, in the most regular and pretty Configurations imaginable; and remained so for a long time afterwards.

The Activity and Volatility of Salts are wonderful, and I make no Doubt many entertaining Experiments might easily be made by Intermixtures of vegetable and other Salts, if any body who has Leisure would

intentionally set about it. Kircher says, “ if
 “ you put into a wooden Tube, Tartar,
 “ Quick-lime, Salt, and the Urine of a Wine-
 “ Drinker, reduced into one Mass, which
 “ is to be hardened in the Sun and after-
 “ wards set in a cold Cellar ; from the above-
 “ mentioned Mass, by the Help of Salt-
 “ petre, you will see Flowers branch out.
 “ And such is the Force of Nitre, that, if
 “ in a Glass kept close shut, you pour the
 “ Juices of some nitrous Herbs on the above
 “ Mass, the Nitre contained within it being
 “ pregnant with Spirit will force itself
 “ through the very Pores of the Glass.”

C H A P. LV.

Miscellaneous Observations on Salts, &c.

HAVING gone through the Course of
 my Experiments on saline Substances,
 I propose from thence to form a few Re-
 flections.

As it has been plainly shewn that the
Particles of Salts, dissolved and floating in a
 Menstruum, will by Precipitation, or an
 Evaporation of the Fluid, be brought to-
 gether, and unite in *Figures* peculiar to their
 respective Kinds, by some certain Law of
 Nature, (call we it *Attraction*, or what we
 please :) it seems reasonable to believe, that
 those crystalline, mineral, or metallic fossil
Bodies which have a constant and regular
 Con-

Configuration, derive their *Figures* from the Intermixture and Operation of *Salts* of some Sort or other. For that *Salts* abound every where in the Earth, either at Rest and locked up in Minerals and other Bodies; or in a State of Action, being dissolved and carried along in Water or some other Fluid, is a matter beyond dispute. The finer Particles of such Salts being dissolved *in* and rising *with* the Particles of Water, * float likewise in our Atmosphere in great Abundance, where by Heat and Cold, by a greater or lesser Degree of Rarification, as well as by other Accidents, they at different Times are (in the Air) brought together in greater Quantity, or become more dispersed and dissipated: whence considerable Changes and Alterations are produced, such as Freezing, Hail, Snow, Lightning, Thunder, &c. But I shall confine my Observations to the Effects that are probably owing to saline Particles within the Bowels of the Earth, or very near the Surface thereof.

Since we are acquainted with no *Dissolvents* of Metals where Salts are not principally concerned, it is reasonable to suppose, that in the Bowels of the Earth, Salts may likewise, when dissolved themselves, have a Power of dissolving metallic Substances; and afterwards, on the withdraw-

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* Vitriol, Alum, and Nitre, are so volatile, when dissolved, as to force through the closest Cork, or between the Bottle and the Cork, tho' ever so closely stopped.

ing of the Fluid, of uniting with the metallic Particles, and bringing them together in certain Figures peculiar to such an Admixture, and more or less perfect according to the respective Proportions of metallic, saline, and other Particles. Those curious *Ramifications* in the arboreſcent ſilver Ore brought from *Panama*, which run through the Bed of Stone wherein it lies, may perhaps be owing to the Particles of that Metal having been diſſolved by a vitriolic Menſtrum, and carried along with it into the little Fiſſures of the Stone; where, as the Water evaporated, the Silver Particles were ſhot out and diſpoſed by the vitriolic Salt, into *Ramifications* ſo nearly reſembling the Configurations of Vitriol. The Branchings of *Copper* and *Iron* (by ſome imputed to a vegetative Principle) are probably produced in a like Manner: and the Reaſon why *Gold* is ſeldom or never found thus branched, but always in little Lumps or Granulæ, may perhaps be, that the Salts which diſſolve other Metals are unable to ſeparate the Particles of Gold.

Rock Salt, (which differs little or nothing from the Salt of Springs and of the Sea,) *Vitriol* and *Alum*, (of which, and alſo of *Sulphur*, the ſaline Acid, Chemiſts tells us, is in all the ſame) *Nitre* and *Borax*; are I think the only foſſil or mineral Salts ſpoken of by Writers; for *Salt Ammoniac* can hardly be accounted ſuch. But it is impoſſible

to say what others besides these the Bowels of the Earth may contain, or how infinitely they may be compounded and diversified. I shall make no Difficulty to suppose the *component Particles* of Spars, Crystals, and precious Stones have been *separated* and *floating* in some Fluid, and brought together in the Shapes we see them by certain Laws of Attraction, which in like Circumstances are constant and unalterable. And as uniting in regular Order, and forming Masses of Figures *uniform* and *constant*, are the distinguishing Properties of Salts, (as the foregoing Experiments shew) the *component Particles* of Bodies thus formed must originally have been *Salts*, notwithstanding the Bodies so composed are indissolveable: nor is the present fixt Condition of such Particles, or the Hardness of such Bodies, any conclusive Objection; for the making of Glass shews, that Salts may be rendered fixt, hard, and indissolveable. I therefore apprehend that all *crystalline Matter*, or the Particles of Matter whereof Spar, Crystals, and precious Stones are formed, is originally a *Salt*, according to my Meaning of the Word; and *Linnaeus* is I presume of some such-like Opinion, since in his *Systema Naturæ* he places all precious Stones, even the *Diamond* itself, in his Classes of *Salts*.

Doctor *Woodward* likewise, though he speaks not of this crystalline Matter as a Salt,

imputes to it the Properties that Salts have, when he says, *the shooting of any Metal proceeds generally, merely from Crystal, combining with it in the Concoction and Formation of the Mass.* And again, *Metalline Matter, when pure and simple, never shoots into an angulated Figure, nor is indeed capable of doing that.* *The Bodies incorporated with Metals, and disposing them to shoot into angulated Figures, are either Sulphur (by which he must mean the Sal Acidum of Sulphur), or Crystal.* “*Iron concreting with Crystal determines it to a rhomboidal Figure, Tin to a quadrilateral Pyramid, Lead to a cubic Form.* If Crystal be pure it shoots into a *six-sided pyramidal Figure, or into a Pyramid erected upon a Column, each with six Sides and Angles.*” He moreover supposes, “*the Basis of all transparent Gems to be a crystalline Matter different in Hardness, and coloured by metallic Mixtures: Lead imparts a yellow, Tin † a black, Copper a blue or green, Iron a purple, an amethystine, and various Sorts of red.* The Figures of all angular opake Fossils are owing to the like crystalline Matter, but in them the metallic Matter so much exceeds the crystalline, as to render the Body opake” ‡.

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† And sometimes a yellow, as several large Grains of Tin in my possession prove.

‡ See Woodward's Fossils. Vol. I. pag. 188, and 220.

That the Shoots of Crystals are formed in a Fluid strongly charged with crystalline Matter, will readily I believe be granted, and likewise that their Formation is nearly in the same Manner as the Formation of the Crystals of dissolved Salts. But perhaps it may be inquired in what Time this Operation is brought about ; and though that much depends on the Strength of the Solution, and the Evaporation of the watery Part of the Fluid, there must certainly be a *Crisis* when the Crystals begin to form ; after which, little Time perhaps is required to bring them to Perfection : for, when the *floating Particles* come within the Sphere of each other's Attraction, they *rush together* and *unite*, according to their respective Figures, and that in a short Time ; as is plain in *freezing*, and in artificial Crystalization, which is brought about in the same Way.

Great Disputes have arisen among *Naturalists* concerning the Formation of *Corals* and *Corallines*, * under which Names Bodies of very different Contextures, Substances and Figures, are I think too indiscriminately included ; their Appearance indicating not only a Difference in Species, but even in Genus. Some insist on their being in general
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* As I think it needless to enter into Particulars, by *Corals* and *Corallines* I intend, in general, whatsoever the Naturalists include under the Names of *Corallium*, *Millepora*, *Medusipora*, *Corallina*, &c.

the *Work of little Animals*, whilst others maintain that they are all *Sea-Plants*. There may be found perhaps of *both* these Kinds : but is there not a *Third*, (I mean the *stony Corals*) whose Production may be more akin to that of Minerals, and chiefly owing to the Operation of *saline Particles* incorporated with *stony Matter* ?

The Rocks in the Sea on which these Corals are produced, are undoubtedly replete with *mineral Salts*, some whereof near their Surface, being dissolved by the Sea Water, must consequently *saturate* with their *saline Particles* the Water round them to a small Distance, where blending with the † *stony Matter* with which Sea Water always abounds, *little Masses* will be constituted here and there and affixed to the Rocks. Such adhering Masses may be termed *Roots* : which *Roots attracting* the saline and stony Particles, according to certain Laws in Nature, may

† I call those Corals *stony* which have a Hardness like unto Stone ; and would be understood to mean by *stony Matter*, that Matter which constitutes the Basis of such Corals ; without any critical Enquiry whether it is or is not different from that Kind of Matter whereof some Stones are made.

Dr. Woodward says, “ the true marine Coral is indeed a
“ stony Substance, and of mineral Nature and Origin : the
“ constituent Matter of it is beat off from the Rocks and
“ Cliffs, (where the Agitation of the Sea is great,) borne
“ thence, precipitated, and affixed to Rocks, Stones, Shells,
“ or other Things, where the Water is more still and calm.
“ As it is of the same Constitution, so it owes its Solidity and
“ the Cohesion of its Parts to the same Cause that Stones and
“ and other Minerals do.” *Hist. Fossils Class V. Vol. 1.*
pag. 129.

may produce *branched* or *other Figures*, and increase gradually by an Apposition of Particles; becoming *thicker* near the Bottom where the saline Matter is more abounding, but *tapering* or *diminishing* toward the Extremities, where the mineral Salts must be fewer, in proportion to their Distance from the Rock whence they originally proceed. And the different Proportions of *mineral saline Particles*, of the *stony* or *other Matter* wherewith they are blended, and of *marine Salt*, which must have a considerable Share in such Formations, may occasion all the Variety we see. Nor does it seem more difficult to imagine that the *radiated*, *flarry*, or *cellular Figures* along the Sides of these Corals, or at the Extremities of their Branches, may derive their Production from *Salts incorporated with stony Matter*, than that the curious *Delineations* and Appearances of minute Shrubs and Mosses on Slates, Stones, * &c. are owing to the *Shootings of Salts* intermixt with *mineral Particles*: and yet these are generally allowed to be the Work of *mineral Steams* or *Exhalations*; by which must, I think, be meant the finest Particles
of

* Let me not be misunderstood to mean the *Impressions* of Plants found frequently on Slates, Iron-Stones, &c. for such *Impressions* are undoubtedly owing to the very Plants themselves, whose Figures they bear, having been lodged in the Matter whereof such Slates or Stones are made, whilst it was in a fluid or soft State; which they serve to prove it formerly has undoubtedly been.

of some Metal or Mineral incorporated with and brought into Action by a volatile penetrating Acid, which carrying them along with it into the Fissures at least, if not into the solid Substance of such Stones or Slates, there determines them to shoot into these *elegant Branchings*; after the same Manner, and frequently in the same Figures, as the *Particles of Mercury, Copper; &c.* are disposed and brought together by the Salts in *Aqua Fortis*, of which an Account is before given pag. 196.

Such as believe these Corals to be the *Work of Insects*, ground their Opinion, (against many seeming Appearances to the contrary,) on the sole Supposition that each of their *starry Cells or Hollows* is inhabited by *an Insect*, who therefore was the Maker of it. I very readily believe *Insects* are frequently found therein; for the Works of God are all subservient to one another, so as to compose a perfect Whole; and as on the Earth most Kinds of Plants afford an *Habitation for Insects*, it would be very strange if amongst the innumerable Animals in the great Sea, some Species or other were not intended to dwell in these little Cells. But without objecting to the *Disproportion* between the Work and the Workmen, and that Animals so exquisitely tender and delicate should yet be able to bring together and fashion such large and heavy Masses of Stone-like Matter, since Na-
ture

ture is every where wonderful ; I shall only remark, that were all these Cells filled with Animals, and especially the very large Cells in some Corals, to which the Animals must be supposed proportionably large, it could scarce have happened but that every Fisher for Coral, or whoever had seen a Branch of it in the Sea, must likewise have seen these Animals. Besides, at different Times, there have been some *diligent Observers* of Coral, whose Notice these Animals have escaped ; which renders it probable, that tho' *some* Cells may be inhabited, the *Generality* of them are not. And as to forming Conclusions from the *minute Corallines*, whose Substance and Figure bear not the least Resemblance to these, and insisting that because the little Vessels or Cases found on them are the *Nests* and the *Works* of Insects, therefore Insects must have been the Fabricators of all the Corals ; I say, to conclude thus, is somewhat over-hasty and unphilosophical †.

Though

† The Animals supposed to have *formed* Corals, or to have *made their Nests* upon them, are, for want of knowing their proper and distinguishing Characters, called at present by the general Name of *Polypes* ; though perhaps their Species, Size, and Figure may be as different as the Corals themselves are : but these Animals are described by all who speak of them, as having Bodies so extremely tender that a very slight Touch will lacerate or disorder them. They are also represented as *fixt* to one Spot, with little other Motion than that of *extending* their Arms or Bodies out of their Cells, or *contracting* themselves and retiring therein at the Apprehension of Danger. Creatures thus circumstanced seem very little capable of collecting

Though, living far from the Sea, I have never been able to examine *Corallines* just taken from thence, I doubt not the Veracity of those who say, that on placing them conveniently in Sea Water, they have by Glasses discovered minute *Polypes* in every one of the little Vessels: but these Vessels or Cases are of a membranaceous Texture, transparent, and in most Particulars intirely different from the *stony Corals*; and even allowing them to be the Work and Nests of Insects, I am not yet, I must confess, intirely convinced that the whole *Coralline* is so too; for in many of them a tough Stem, seemingly of like Consistence with that of other Sea-Productions acknowledged to be Plants, rises from a Root or what appears to be so, and branches out in such a Manner, that I believe the most accurate Examiner, *void of any Hypothesis*, would declare it to be vegetable.---In short, there are wonderful Mixtures in the Sea; Stones, Shells, and Plants, are

lecting and carrying a *stony Matter*, and raising *Edifices* therewith; and especially in such large Quantity, that comparing the *Smallness* of the Cells wherein these Creatures are supposed to dwell, with the *Bulk, Solidity, and Weight* of the Roots and Branches of many of the *Stony Corals*, the greatest Part of it appears quite unnecessary. This is directly contrary to the Oeconomy of Nature, (*frugal tho' sufficient*) in the Shelly Cases of the several Species of *Vermiculi*, in the *Tubuli marini*, the *Pipe Corals*, and the Habitations made by other small Insects; all which, like the *Honey-comb*, are framed of as little Matter as possible, thin, light and roomy, and appear to be what they are. I shall only add, against the Supposing *all Corals* to be made by Insects, that some Sorts have no Cells either on their Stems or Branches.

are frequently incruſted with the ſtony Matter that gives the Subſtance to *Coral*; and I make no Doubt that Millions of minute Animals find or build them Habitations both on the *Corals* and the Sea-Plants.

But to leave a Digreſſion, which is not perhaps quite foreign to my Subject, and wherein I would not be thought to affirm any thing, but only to point out how the *ſtony Corals*, which are certainly formed by an *Appoſition* of Particles ſome how or other brought together, (having no *Fibres* or *Veſſels* to convey Juices for Nutrition or Increate, and therefore being no *Vegetables*) may poſſibly be produced with all their beautiful Regularity and Variety, even tho' on a ſtricter Enquiry they ſhould not appear to be made by *Inſects*. †.

The Salts of Minerals and Vegetables floating in the Air produce a thouſand pretty Appearances, when brought together and concreted by *Froſt*. I have ſeen, in Winter
Time,

† The Reader is intreated not to hurry over this Subject too haſtily, but to examine with due Attention the ſeveral Sorts of *Cryſtals*, *Spars*, &c. and he will find amongſt them many whoſe Shootings are as regular and uniform as thoſe of *Coral*, and their Variety perhaps as great; yet all theſe are allowed by *Naturaliſts* to derive their Subſtance and Form from *crystaline Matter*, combined with different Sorts or Proportions of *metallic*, *ſtony*, *earthy*, or other Subſtances. Let him particularly examine and conſider the *Ludus Helmontii*, the *ſtarry waxen Vein*, the *Ericæ-formis* or *Heath-like Spar*, the *vegetative Silver*, *Copper* and *Iron-ores*, and all the regularly figured *Cryſtals*, *Spars*, *Marcaſites* and *metallic Bodies*.

Time, formed in this Way, upon Windows, on wooden Pales, and sometimes on the Webs of Spiders, very elegant Representations in Miniature of Landscapes, with Groves of Trees, and a seeming Variety of Shrubs and Herbs : but the most charming of this Kind I ever beheld used to be on the Glass Windows of a necessary House in the Country, owing I suppose to the additional Intermixture of animal Salts.

Copper Plates are very expensive, and Descriptions without them hardly intelligible, or I should have added many curious Observations made on Mixtures of animal, vegetable, and mineral Salts, (some of which are in very few † Hands) as also on the Solutions of different Metals and Minerals by *acid Spirits* ; but those who know any thing of Chemistry, or will bestow a little Time in the Study of Nature, will, I am persuaded, in Consequence of the Hints here given, suggest to themselves numberless Experiments, which if pursued may prove both profitable and pleasant.

In short, *Salts* are the active principles whereby Nature performs Wonders ; as is sufficiently

† Particularly the *Natron* of *Egypt*, brought thence and given me by Dr. *Pocock* ; an alkaline Salt fermenting violently with Vinegar (whose Shootings are very singular) from *Sindy* in the Inland Parts of *Asia*, given me by Sir *Hans Sloane* ; the genuine *Salts* of mineral Springs in different Parts of the World ; and many other *saline Substances* either in their natural State, or by human Art extracted or compounded.

sufficiently evident from that Variety of Figures they produce, by combination with one another, or when incorporated with Substances of other Kinds. But this has given occasion for some to object, that the Figures of Salts cannot be determined, since the same *Acid* dissolving different Bodies assumes different Shapes. *Spirit of Nitre*, say they, for Instance, having dissolved *Copper* shoots into hexagonal Chrystals, having dissolved *Iron* into irregular Squares, and forms triangular thin Crystals after dissolving *Silver*. But waving all Dispute, which I shall ever carefully avoid, does not this seem a Proof rather of their Constancy than their Uncertainty? for the Shootings of pure Nitre examined alone are constantly the same; and are not the Chrystals produced in *Spirit of Nitre* when *Copper*, *Iron*, or *Silver* has been dissolved therein, always constant to each respective Metal, though different from one another? What greater *Constancy* than this can possibly be expected? and would it not occasion much greater Uncertainty and Confusion were *mixt* and *unmixt* Substances to put on the same Forms? --- It is likewise objected, that their Figures vary if they are differently prepared: And this indeed is true. But as with the same Mixtures or Management they are found to produce the same Crystals and Configurations, this Objection has no Force; unless it be to prove,

Q

that

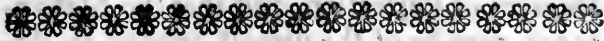
226 *Miscellaneous Observations on Salts, &c.*
that the Figures they produce are *distinguishing* and *infallible Marks* of their different Degrees of Perfection, and that the MICROSCOPE may be of the utmost Service to discover Knavery and Imposition.

End of PART the First.



ADVERTISEMENT.

AS many of the CURIOUS, who desire to keep *Solutions of Salts* in Readiness for Examination, may chuse to save themselves some Trouble; Mr. CUFF, Optician, against *Serjeants-Inn Gate* in *Fleet-street*, can furnish them with Boxes of different Sizes, neatly fitted with Phials and Slips of Glass for that Purpose. This may be an Ease to them, and 'tis hoped will prove of some Advantage to him.



EMPLOYMENT
FOR THE
MICROSCOPE :

PART II.

CONTAINING

An Account of various ANIMALCULES
never before described; and of many
other *Microscopical Discoveries.*

WITH

OBSERVATIONS and REMARKS.

ALSO

A *Description* of the *Microscope* used in
these Experiments : and of a new *Mi-*
crometer serving to shew the comparative
Size of magnified Objects.

TOGETHER

With *Instructions* for easily printing off any
Medal or *Coin.*





INTRODUCTION.

THOUGH every Thing is *alike easy* to an Infinite and Almighty BEING; yet, according to human Comprehension, it appears extremely wonderful, that we find, almost without Exception, in those *Specks of Life* whose Minuteness renders them almost imperceptible to the Eye of Man, a greater Number of Members to be put in Motion, more Wheels and Pullies to be kept going, a greater Variety of Machinery, an Apparatus more complex and curious, a Plan seemingly of deeper Contrivance; in short, more Elegance and *Workmanship* (if the Term may be excused) in the Composition, more Beauty and Ornament in the Finishing, than are seen in the enormous Bulk of the Elephant, the Crocodile, and the Whale; compared with which, one would think them no less the Effect of a more exquisite and superior Art, than the Movements of a Watch appear to be, on Comparison with the Wheels of a Coach or Waggon.

These Truths need no Proof to such as are acquainted with the MICROSCOPE, however incredible they may seem to others: that valuable Instrument will fully convince us, that *All the Works* of the CREATOR well deserve our most diligent Attention; that Perfection appears every where; that Minuteness is no Mark of Meanness; and that nothing is so *little* or so *low* but that it can richly repay our Enquiries. Hereby we are likewise taught, that an Atom to *Omnipotence* is as a World, and a World but as an Atom; in the same Manner as to *Eternity* one Day is as a thousand Years, and a thousand Years but as one Day. Every Species of these Animalcules may also usefully serve to correct our Pride, and prove how inadequate our Notions are to the real Nature of Things: by making us sensible how little of the larger or smaller Parts of the *Creation* could possibly be made for us; who are furnished with Organs capable of discerning to a certain Degree only of the *great* or *little*, all beyond which is as much unknown, as far beyond the Reach of our Conception, as if it had never been.

An Examination of the Variety and Beauty of the *Works of Nature* must afford the most reasonable Satisfaction to a contemplative Mind, as they strongly evince the Agency and Omnipotence of the DEITY. Proofs of some all-powerful, wise and good Being
are

are indeed deducible from every thing around us, but the *extremely Great* and the *extremely Small* seem to furnish the clearest and most convincing; and perhaps, if duely considered, the Fabrick of a *World*, and the Fabrick of a *Mite* may be found equally striking and conclusive.

GLASSES discover to us numberless Kinds of living Creatures, whose Minuteness renders them absolutely undiscernable by our naked Eyes, and God alone knows how many thousand Kinds there may be, still gradually decreasing in Size, which it is impossible for us to see by any Help whatever; to all these, however, we must believe, from reasoning on what we know, that Providence has not only appointed the most wise means for Propagation, Preservation, and Happiness, but has moreover adorned them with Beauty equal at least to any thing our Eyes have ever seen.

The smallest living Creatures our Instruments can shew are those that inhabit the Waters: for though possibly Animalcules no less minute may fly in the Air, or creep upon the Earth, it is scarce possible to bring such to our Examination; but Water being transparent, and confining the Creatures in it, we are able, by applying a Drop of it to our Glasses, to discover (to a certain Degree of Smallness) all that it contains. My Attention has been therefore applyed more particular-

ly to inspect the Waters; in doing which I have been kindly assisted by some ingenious Friends; and the following *Plates* and *Sheets* exhibit the *Figures* and *Descriptions* of such of the minute Inhabitants thereof as have fallen in my Way, and seemed to me the most curious and extraordinary. And as *Names* are of the utmost Service to make People understand one another, I hope to be indulged the Liberty of giving such to these hitherto unnoticed Animalcules, as correspond in some manner to their Appearances; even though I may not always have chosen the most proper.



EMPLOY,



EMPLOYMENT FOR THE Microscope, &c.

PART II.

CHAP. I.

Of the HAIR-LIKE Insect.

THE wonderful Animalcule I am going to describe, was I believe first taken Notice of by my curious Friend Mr. *William Arderon*, of the City of *Norwich*, before spoken of in this Treatise, who kindly sent me an Account thereof, together with many thousands of the Creatures themselves; which came to me alive, in a Vessel of the same Water they were found in, and lived with me several Weeks : whereby I had frequent Opportunities of being convinced how carefully he had observed them, and likewise enabled to relate many Particulars from my own Knowledge.

This

This little Animal (the Form whereof may be seen *Plate X. N^o I.*) is extremely slender; and not uncommonly one hundred and fifty times longer than broad. Its Resemblance to an Hair has induced us to call it the *Hair-like Insect*. The Body, or Middle Part, which is nearly strait, appears in some composed of such parallel Rings as the Windpipe of Land Animals consists of, but seems in others scaled, or rather made up of Rings that obliquely cross each other. This Difference may be seen in the two Figures F, G. Its two Ends are bent, or hooked, pretty nearly in the same Degree, but in a Direction contrary each to other; and, as no Eyes can be discerned, 'tis difficult to judge which is the Head or Tail.

Its progressive Motion differs from that of all Animals besides hitherto described, for notwithstanding the Body is composed of many Rings and Joints, it seems unable to bend at all, or move directly forwards: but when it is inclinable to change its Quarters, it can move from Right to Left, or Left to Right, and proceed at the same time backwards or forwards obliquely. And this it performs, by turning one End about, the Quarter of a Circle, as the Arc *a b* shews; then it does the same with the other End, and so alternately: whereby its Progression is in a diagonal Line, or from Corner to Corner; as whoever will take the Trouble

to

to shift the Points of a Pair of Compasses in that Manner may immediately be satisfied.

All its Motions are extremely slow, and require much Patience and Attention in the Observer. It has neither Feet, nor Fins, nor Hairs, but appears perfectly smooth and transparent, with the Head bending one Way and the Tail another, so as to be like a long Italian *f*: nor is any internal Motion, or particularly opake Part to be perceived, which may determine one to suppose it the Stomach or other of the Intestines.

These Creatures are so small that Millions of Millions might be contained in an Inch Square. When viewed singly, or separated from one another, they are exceedingly transparent, and of a lovely green; but like all other transparent Bodies, when Numbers of them are brought together they become opake, and lose their green Colour, in proportion as the Quantity increases, till at last they appear intirely black.

They were first discovered in a Ditch at *Norwich*, one End whereof communicates with the River there, and the other End with a second Ditch, into which several Kennels empty themselves from different Parts of the City. The length of this Ditch is at least an hundred Yards, and its Breadth nine: the Bottom, for more than a Foot in Depth, is covered with a blackish green Substance, in Appearance like a Mud, made up wholly

wholly of these and other Insects, intermixed with different Sediments from the Water. He assures me, he has constantly found much the greater Part of this black Matter to be really Insects: but were they only one half or a quarter Part thereof, what Numbers beyond all Conception must this Ditch contain?

It was Accident (whereto more Discoveries have perhaps been owing than to Design) that fortunately presented these Animalcules to Observation. --- My Friend having got some Water from this Ditch, with Intent to examine by the Microscope other Insects he had taken Notice of therein, found before his Eyes a great Abundance of slender Hair-like Fibres, which he imagined to be the Stems or Roots of some extremely small Water Plants, from their appearing to him without any Life or Motion, tho' he wondered much at their uniformity of Figure. Being however not satisfied with a single View, but continuing them under the Magnifier, and looking at them now and then, he perceived that many of those seeming Hairs which he had seen before separated from one another as at *d*, in N^o. II. were slowly drawing themselves together in Companies as at *e* in the same Number. --- This gave him the first Notion of their being living Creatures, and set him upon watching them so narrowly, that he was quickly convinced,

vinced, not only of their having Life, but likewise of their being able to change their Situation, either from Right to Left, or Left to Right, backwards, or forwards, at Pleasure, in the Manner just now described.

Being thus far satisfied, he applied himself very diligently to examine the Structure, Motions, and other Properties of these minute Creatures; and found, by viewing them several times, and through different Magnifiers, that altho' they are most commonly composed of little Ringlets, whose Joynings appear like parallel transverse Lines as at F, N^o I. many however were seen amongst them, in which great Numbers of minute Rings seemed to cross one another obliquely, and represented Scales, (*vid.* N^o I. G.) but whether these are different Species or not must still remain a Doubt.

After putting a large Spoonful of the beforementioned black or rather dark green thick Matter into a Glass Jar, he filled it up with Water, very gently, as high as *b*, N^o III. then leaving the said Matter to settle and lie quietly at the Bottom of the Vessel, its whole Appearance presently afterwards is shewn in the same Glass at *i*.

The next Day, when he came to examine what had happened amongst these Myriads of little Animals, he found that a Multitude of them had, as it were by Agreement, placed themselves on the Side of the Jar, and appeared

peared marching upwards in Rows, after the Manner represented N° IV. *l.* and that some of them had travelled to the Distance of three or four Inches, which considering the Slowness of their Motion, and their Method of moving forwards, must be looked upon as a long Journey.

In about two Days great Numbers had travelled up the side of the Jar, to above the Surface of the Water, as at *k* N° IV: when after being exposed to the Air for a little while, their fine green colour became changed into a most beautiful Sky-blue.

This fine dark green Matter or Congeries of Animalcules, is so nearly equal to the specific Gravity of Water, that at first putting in, it either floats at Top, or continues at the Bottom, or in the Middle of the Jar, just as Accident has disposed it. But if Part of those that are swimming at the Top of the Water have an Inclination to go downwards, they form themselves into a Sort of Line or Rope, which descends extremely slow, till they arrive as low as they intend: And they are able to suspend themselves in the Water where they please, and as long as they have a mind. Their Method of doing this is shewn N° V. *c c c.* Those however who happen to be near the side of the Jar move themselves down thereon, and that commonly in a winding screw-like Manner, as *n n* N° V. is intended to represent.-- Their
Motion

Motion upwards in the like Order has been described already, N^o IV. 1.

A small Quantity of this Matter having one Day been put into a Jar of Water, it so happened that one Part thereof went down immediately to the Bottom, whilst the other Part continued floating upon the Top. All Things remained a good while in this Condition, until at last each of these Swarms of Animalcules grew weary of its Situation, and had a Mind to change its Quarters. Both Armies, in short, began their March at the same Time, against the side of the Jar; and as one proceeded upwards, and the other downwards, after some Hours, they were near meeting about the Mid-Way; as the Rout each of them appeared to take, soon after they began to move, made it very easy to foresee they would. The Desire of knowing in what Manner they would behave on this Occasion, engaged the Observer to watch them with a careful Eye, and as they approached still nearer, he beheld, to his great Surprize, the Army that was marching upwards, open to the Right and Left, and leave a convenient Space for the Army that was marching downwards to pass between its Wings. Thus without Confusion or Intermixture each held on its Way: the Army that was going upwards marching in two Columns to the Top, and the other proceeding with great Regularity and Order in
one

one Column to the Bottom. N^o VI. is a Representation of this amusing Accident, which serves to shew, that however mean or contemptible these Creatures may appear to us, the Power that created them has not left them destitute of Sagacity, to associate together, and act unanimously for the Benefit of the Community; both these Armies marching as regularly as if under the Direction of wise Leaders.

When these Animalcules are taken from the Ditch, and any other Water poured upon them, it is difficult to make them live twenty-four Hours; but when kept in some of the same Ditch-Water, they may be preserved in good condition for several Months. Though they never are so vigorous, nor shew their Way of moving from Place to Place so plainly, as when newly taken up.----Their Kind of Motion, as before described, makes it evident, that if they move along the Side of a cylindrical Glass Jar, either upwards or downwards, it must be in a Spiral Line; and such it is always found to be.

It is not yet discovered whether their Food be Insects excessively minute, or Particles of Matter floating in the Water; neither do we know any thing concerning the Manner of their being propagated. They have as yet been taken notice of only in this Ditch, but 'tis reasonable to believe that other Places of
the

the like Kind, will, upon Examination, be found to produce them also, and even in great Abundance.

C H A P. II.

Of the OAT-ANIMAL.

IN the same Ditch-water from *Norwich* came likewise great Numbers of the little Creatures, whose several Appearances, when examined by the Microscope, are shewn *Plate X. N^o vii.*

My curious Friend pointed it out to my Observation by the Name of the *Oat-Animal*; and as, at first View, it much resembles a Grain of that Sort, I shall here describe it under the same Name.

This Creature is so very small, that no true Judgment can be made of it, unless it be looked at through the greatest Magnifier, nor even then without considerable Attention. I commonly found two or three of them in a Drop of the Sediment, amongst Multitudes of the *Hair-like Insect*, lying at the Bottom of the Water wherewith the said Sediment was diluted, upon the Plate of Glass, without any visible Motion or Appearance of Life: being inclosed in a Bivalve-shell, which the Animal can open or shut as it is inclined; but which it

constantly shuts upon being disturbed, nor opens again until after having been quiet for some Time. Its Appearance when shut is pictured at *fig. 1.*

The Shell is so exquisitely thin, and consequently so very transparent, as to be traced out, when shut, only by a faint Line on the Back, where the *Cardo* or *Hinge* makes some additional Thickness; but when open, the Edges of both its Sides may be distinguished plainly. The two Ends of the Shell can open, whilst the middle Part remains closed, and in that Condition it is like the *Pholas* and some Species of the *Chama*; but differs from them, in being able to shut both Ends and alter the Figure of its Shell, which they cannot do. This probably is performed by means of certain Articulations in the Shell, near its Extremities, which are too fine to be discerned. When these Ends are open, the Creature frequently thrusts out, at each, a cylindrical fleshy Part, (as at *fig. 2.*) which may be supposed the Head and Tail; but their Minuteness renders it hardly possible to discover any difference between them. In this Posture it is probable the Creature feeds, on that Provision the Water brings; though it depends not wholly on such Accident, for it can change its Place by Jerks, or Leaps, which it makes by the Action of some strong Muscles in the two protruded Parts,

Parts, whose Spring throws it to the Distance at least of its own Shell's Length every Time they are exerted. These Leaps however have long Intervals between, and are never made till the Animal is perfectly undisturbed.

Both the Shell and Body are usually so transparent, that when the Shell is closed nothing can be perceived but a Sort of Shade within it: but, now and then, I have seen the Body, plainly, through the Shell, in Shape as at *fig.* 3.

Several of them have a couple of very dark round Spots, one whereof is seemingly placed within each Side the Shell, as in *fig.* 4. These I imagined to be compact Ligaments, serving to open and shut the Shell, and correspondent to those that Oysters, Muscles, Scallops, &c. are furnished with for the like Purpose. But when I observed others of them, having three, four, or five of the same round Spots, I began to think myself mistaken; and should rather suppose them concreted Bodies, similar to the Pearls bred in several kinds of Shell-fish, did not the Regularity of their Position render this likewise a little improbable.

One, having five Spots, with its Shell gaping the whole length, and both Ends thereof fully extended in a strait Line, very different from what precede, is ex-

hibited *fig. 5.* — In this Condition, which is not uncommon, it much resembles a Grain of Oats.

I must not omit to mention another Variety amongst these Creatures, which the *fig. 6, 7, and 8,* are intended to explain. Here we see a couple of transverse Lines, forming a kind of Zone across the middle Part of the Shell, and seeming to separate the two Ends thereof.

Fig. 6 and 8 have the two round opake Spots before described.

Fig. 6 and 7 shew the Cardo of the Shell, but the same is not seen in *fig. 8.*

'Tis difficult to determine whether these are another Species, or only some of the same Sort of Animals in a different State or Condition. I much suspect they may be about casting their Shells, or perhaps distemper'd, or even dead; for I have never seen any of them open their Shells, or make the least Motion, though I have sometimes kept my Eye over them for above a Quarter of an Hour.

C H A P. III.

EELS *in PASTE* viviparous.

THE *Anguilla*, or little *Eel-like Animals*, which are frequently so numerous in *four PASTE* that the whole Surface

of it appears alive, and are seemingly of the same Kind with those sometimes found in Vinegar, were some of the first minute Creatures the Microscope was made use of to examine, and are still the most common living Objects it is employed about; I should not therefore, after their having been so long known, and so often described, have introduced them here, had not a very pretty Discovery made a few Years ago, by Mr. *James Sherwood*, an ingenious young Surgeon, rendered them the Subject of a curious and entertaining Experiment.

Separating one of these small Eels from a Number of others, in order to examine it by the Microscope, and wounding it accidentally in the Belly, he took Notice that a long slender Tube, doubled like an Intestine, proceeded from the Wound: of which informing Mr. *Needham*, it excited their Curiosity to cut in two another Eel, near its Middle: when they discovered a Number of *living young ones*, each inclosed in its proper Membrane, issuing from what now plainly shewed itself to be the *Uterus*. This induced him to make farther Trials, and finding usually the same Appearance, he thought proper to communicate his Observations to his Friends, and afterwards to the Royal Society*.

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* *Philos. Trans.* No. 478.

I first saw the Experiment with Mr. *Sherwood*, and having since made it abundance of Times myself, am qualified to direct those who may desire to be satisfied, how to perform it themselves, without any great Difficulty.— Having taken up a very small Quantity of the *Paste* where these Eels abound, on the Point of a Pin, or with a sharpened Quill, lay it on a slip of Glass; and diluting it well with Water, many of them will become visible to the naked Eye: then with the nib of a Pen cut to a very fine Point, and shaved so thin as to be extremely pliable, single out one of the largest Eels, and insinuating the Point of the Pen underneath it, remove it into a very small Drop of Water, which you must have ready prepared on another slip of Glass. When thus confined, it may easily be cut asunder, transversely, by the Help of a good Eye and steady Hand, with a Lancet or sharp Penknife; or if the Eye is deficient, a Hand-Magnifier will enable almost any body to perform the Operation. As soon as the Parts are separated, apply your Object to the Microscope, and if the Division has been made about the Middle of the Animal, several oval Bodies of different Sizes will be seen to issue forth. These are young *Anguillæ*, of different Degrees of Maturity, each whereof is coiled up and
included

included in its proper Membrane, which is of fo exquisite a Fineness as to be scarce discernable by the greateft Magnifier, while it inclofes the Embrio Animal. The largest and moft forward break immediately through this delicate Integument, unfold themselves, and wriggle about in the Water nimbly: others get out, uncoil, and move about more slowly; and the leaft mature continue intirely without Motion. The *Uterus*, or Veffel that contains all thefe oval Bodies, is compofed of many Annulæ or Ringlets, not unlike the *Aspera Arteria* of Land Animals, and it feems to be considerably elastic; for as foon as the Operation is performed, the oval Bodies are thruft out with fome Degree of Violence by the fpringing back or Action of this Bowel. An hundred and upwards of the young ones have been feen to iffue from one fingle Eel, whereby the prodigious Increase of them may be accounted for; as probably feveral fuch numerous Generations are produced in a fhort Time. Hereby we alfo learn that thefe Creatures are not only like Eels in Shape, but are likewise viviparous as Eels are generally fuppofed to be.

I fcarce know a more entertaining Experiment; and you'll very feldom be difappointed, for they feem like *Earth-worms* to be all prolific, and unlefs by Accident

you cut one that has brought forth all its Young before, or make your Trials when the PASTE has been kept a very long Time, (in which Case I have found them sometimes unfruitful,) you'll not fail of being diverted after the Manner above described,

One of the *Anguillæ*, greatly magnified, and through the Body of which, before cutting, faint Traces of the young ones may be discerned, is shewn, N° VIII, Plate X.

The same, after being cut, with young ones issuing from it, and the *Uterus* as it usually appears, is represented in a Drop of Water, N° IX.

This Discovery is of more Consequence than without due Consideration it may seem to be; for as these Animalcules are plainly viviparous, and bring forth *living* and *perfect young ones* in their Eel-like Form, it is highly improbable that they ever become Flies, or undergo any other Change; since no Animal has been yet known to put on a new Shape after it has produced its Young, whether in the Egg or otherwise. Therefore if these *Anguillæ* never change to Flies, or lay Eggs, which this Experiment renders it very unlikely they should ever do, they can neither convey themselves to any Distance from the *Paste* wherein they first appear, nor be propagated by Eggs floating in the Air. The

Question

Question then will be, by what Means they get into the *Pafte* at all: for fupposing it poffible they might have been in the Wheat; and have efcaped unhurt through the feveral Operations of grinding the Corn; fifting it, &c. it is fcarcely credible (in whatever Condition they might remain in the Flour) that they fhould be able to endure boiling, without which, and that too for a confiderable Time, no good *Pafte* can be made.

For my own Part, I muft acknowledge, that before this Difcovery I was ftrongly of Opinion that thefe Eels change into Flies; as many Kinds of Worms found in Waters are well known to do, and in that State deposit their Eggs in whatever Places they find a proper Nest and Provision for their future Offspring: and this my Opinion I thought confirmed, by fometimes obferving very minute Flies, of a Size agreeable to fuch a Suppofition, hovering about the Glaffes where *Pafte* with Eels was kept. But as bringing forth living young ones, in their Eel-like State, is a Fact beyond all Doubt, I muft believe the Flies I faw about the *Pafte* are Infefts of fome other Kind, and have no Relation to thefe Eels; unlefs we could imagine them to have a two-fold Method of Generation; that is, to be both viviparous and oviparous, and to propagate both in the Eel and in
the

the Fly State; which is too extraordinary a Particularity to be admitted without the strongest Proof*.

These Difficulties must be left to future Enquiry; and I hope the *Curious* will endeavour to solve them by careful Experiments and Observations.

CHAP. IV.

EELS in blighted Wheat.

THE Discovery of a certain Kind of *Anguilla*, or Animalcules resembling *Eels*, in blighted Wheat, was made accidentally by my very ingenious Friend Mr. *Turberville Needham*, in the Summer of the Year 1743, in the Manner described by himself in his curious Book of *New Microscopical Discoveries* †.

These Animalcules are not usually lodged in such blighted Grains of Wheat as are covered externally with a foot-like Dust, (whose

* *Mentzelius* published Observations made on the Process of the Transformation of *Eels in Vinegar*, which, he tells the World, he saw issue in *Flies*; which *Flies* did afterwards lay their *Eggs* in the *Vinegar*, &c. And he has given Drawings of the said *Flies* with his own Hands. On the contrary, *D. Marcus Antonius Cellius* affirmed to the Physico-mathematical Society at *Rome*, Anno, 1688, that with very good Microscopes of his own making he found the *Eels in Vinegar* to be *viviparous*.

† Vid *New Microscopical Discoveries* by Mr. *Needham*, pag. 85.

(whose Inside is likewise frequently converted into a black Powder :) but abundance of Ears may be observed in some Fields of Corn, having Grains that appear blackish, as if scorched; and such when opened are found to contain a *soft white Substance*, that attentively examined seems to be nothing else but a Congeries of Threads, or Fibres, lying as close as possible to each other in a parallel Direction, and much resembling the unripe Down of some Thistles, on cutting open the Flower-Heads before they begin to blow. This fibrous Matter discovers not the least Sign of Life or Motion unless Water be applied to it; but immediately on wetting, (provided the Grains of Wheat are newly gathered) the supposed Fibres separate, and prove themselves to be living Creatures, by Motions that at first are very languid, but gradually become more vigorous, twisting or wriggling themselves somewhat in the Manner of the Eels in Paste, but always much slower than they, and with a great deal less Regularity; for in them the Head and Tail are constantly moving, contrarywise, and alternately, with the same Kind of bending or Undulation in the Bodies of them all; whereas the Animalcules we are now describing have no Uniformity in their Motion, but bend their two Extremities sometimes differently and sometimes in the same Direction.

If

If the Grains of Wheat are grown dry by keeping, and you cut them open in that Condition, the fibrous Matter is very distinguishable, and on putting Water to it will separate with great Readiness, and seem like fine Tubes or Threads tapering at both Ends: but not the least Motion or Symptom of Life will be perceived till they have been in Water for several Hours; nay, frequently they will never revive or come to move at all. But if the same Grains be steeped in Water for some Hours, or buried for three or four Days in Earth, till they are fully saturated with Moisture, and then opened with a Penknife, on taking out a small Portion of the *White Matter* carefully, and spreading it thin upon a Slip of Glass, the Animalcules may be seen bundled together, and extended longitudinally, but without Motion; and tho' upon the Application of Water, they will not revive so soon as those taken from fresh Grains, whose Moisture has never been exhaled; yet, after abiding an Hour or two in Water, I have constantly found them alive and vigorous; and that, notwithstanding the Grains have been kept in a dry Condition even for some Years; of which I have a remarkable Instance now before me.

In the Month of *August* 1743, a small Parcel of *blighted Wheat* was sent by Mr. *Needham* to *Martin Folkes*, Esq; President of the

the

the *Royal Society*, (with an Account of his then new Discovery :) which Parcel the President was pleased to give to me, desiring I would examine it carefully. In order so to do, I cut open some of the Grains that were become dry, took out the fibrous Matter, and applied Water to it on a Slip of Glass ; but could discern no other Motion than a Separation of the Fibres or Threads; which Separation I imputed wholly to an Elasticity in the Fibres ; and perceiving no Token of Life, after watching them with due Care, and repeating the Experiment till I was weary, an Account thereof was written to Mr. *Needham* ; who having by Trials of his own found out the Cause of this bad Success, advised me to steep the Grains before I should attempt to open them; on doing which I was very soon convinced of his Veracity, and entertained with the pleasing Sight of this wonderful Phænomenon. Since then I have made Experiments at different Times with Grains of the same Parcel, without being disappointed so much as once, and particularly on the fourth Day of *July* 1747, finding some of the same Parcel left, I soaked a couple of Grains in Water for the Space of thirty-six Hours, when believing them sufficiently moistened, I cut one open, and applying some of the fibrous Substance to the Microscope in a Drop of Water, it separated immediately; and presented

fented to my View Multitudes of the *Anguilla*, lying as represented N^o X, B, without the least Motion or Sign of Life. But Experience having taught me by former Trials, that they might notwithstanding possibly revive, I left them for about four Hours, and then examining them again, found much the greatest Number moving their Extremities pretty briskly, and in an Hour or two after, they appeared as lively as these Creatures usually are. Mr. *Folkes* and some other Friends were Witnesses of this Experiment.

We find an Instance here, that *Life* may be suspended and seemingly destroyed; that by an Exhalation of the Fluids necessary to a living Animal, the Circulations may cease, all the Organs and Vessels of the Body may be shrunk up, dried, and hardened; and yet, after a long while, *Life* may begin a new to actuate the same Body; and all the animal Motions and Faculties may be restored, merely by replenishing the Organs and Vessels with a fresh supply of Fluid. Here is, I say, a Proof, that the Animalcules in the Grains of blighted Wheat can endure having their Bodies quite dried up for the Space of four Years together, without being thereby deprived of their *living Power*: and since, after they are become thus perfectly dry and hard, there seems little room for farther Alteration, unless their Organs should
be

be broken or torn asunder; may they not possibly be restored to Life again, by the same Means, even after twenty, forty, an hundred, or any other Number of Years, provided their Organs are preserved intire? This Question future Experiments alone can answer.

Some late Discoveries serve to shew our Ignorance concerning the real Effence and Properties of what we term *Life*; and, if modestly considered, may contribute somewhat towards improving and inlarging our Ideas of it. These *Anguillæ*, the *Wheel Animal*, and I doubt not many other Kinds hitherto unobserved, are able to instruct us, that *Life*, or the *living Power*, may be suspended or cease to act for a Length of Time, and yet afterwards may be restored to its former Vigour. The cutting of the *Polype* and *Star-Fish* into Pieces, the Continuance of Life in those Pieces, and their reproducing all the Parts necessary to make each of them a perfect *Polype* or *Star-Fish*, prove beyond all Contradiction, I will not say that *Life* itself may be divided, (lest I should give Offence,) but that an Animal *possessed of Life* may be cut asunder, and the Parts thereof live afterwards, quite separate from and absolutely independent of one another; that all the Members wanting to each Part may be *reproduced*; that, in Time, each Part may become as large an Animal, and as perfect
to

to all Appearance, as that of which it was no more than a maimed and imperfect Part †; and besides all this, that they may multiply, and produce young ones, in as great Numbers, and after the same Manner, as those of their Kind that were never cut.-- These are Truths, the Belief whereof would have been looked upon some Years ago as only fit for *Bedlam*.

What Life *really is*, seems as much too subtle for our Understanding to conceive or define, as for our Senses to discern and examine. We have, I think, no Criterion or sensible Proof whereby to distinguish *Life*, but *Motion*; and there certainly are Motions so *extremely languid*, that they can neither become the Objects of our Eyes or our Ideas; therefore were *Motion* inseparable from *Life*, (which is a Point we cannot I think determine) both might possibly exist in many Bodies where we suppose them not. But whatever be the *Essence of Life*, it is perhaps not to be destroyed, or really injured, by any Accidents that may befall the *Organs* wherein it acts, or the *Body* it inhabits. Dr. *Butler*, the late Bishop of *Durham*, in his ingenious *Analogy of Religion to the Constitution and Course of Nature*, gives it as his Opinion, pag. 21, that “ We have no
“ more

† The Curious may consult on this Subject Dr. Parsons's *Observations on the Analogy between the Propagation of Animals and Vegetables*, pag. 200, &c.

“ more Reason to think a Being endued
“ with *living Powers*, ever loses them, dur-
“ ing its whole Existence, than to believe
“ that a Stone ever acquires them.”---“The
“ Capacity of exercising them for the pre-
“ sent, as well as the actual Exercise of
“ them, may be suspended, (says he, pag.
“ 22.) and yet the *Powers* themselves re-
“ main undestroyed.”

But leaving a Subject, of which we know so little, to speak something farther of our *Anguilla*:—It appears plainly from the foregoing Experiments, that when the blighted Grains of Wheat have been kept a long time, and the Bodies of these Animalcules are consequently become extremely dry, the Rigidity of their minute Vessels requires to be relaxed very gently, and by exceeding slow Degrees; for we find, that on the Application of Water, immediately to the Bodies of these Animalcules when taken from the dry Grains, they do not so certainly revive, as they do if the Grains themselves be either buried in Earth, or steeped in Water for some Time before they are taken out. The Reason of which most probably is, that too sudden a Relaxation bursts their delicate and tender Organs, and thereby renders them incapable of being any more employed to perform the Actions of Life. And indeed there are always some dead

ones amongst the living, whose Bodies appear bursten or lacerated, as well as others that lie extended (in the Manner shewn before, N^o X. B.) and never come to Life, though we can't discover any sensible Injury they have received.

Some Discretion is needful, to adapt the Time of continuing the Grains in Water or Earth to the Age and Dryness of them; for if they are not opened before they have been too much or too long softened, the Animalcules will not only seem dead, but will really be so. Of the two Grains I mentioned to have been four years old when put to soak, I opened one after it had lain thirty-six Hours, and the Event was as already related: the other I let lie for above a Week, and on opening found all the *Anguilla* near the Husk dead, and seemingly in a decayed Condition; but great Numbers issued alive from the Middle, and moved themselves briskly.— Unless the Husks are opened to let these Creatures out after they have been steeped, they all inevitably perish in them; and when taken out and preserved in Water, if the Husks are left with them, they will die in a few Days; but otherwise they will continue alive in Water for several Months together, and, should the Water dry away, may be revived again by giving them a fresh Supply.

Since

Since the Animalcules we find in *blighted Wheat*, as well as those in four *Paste*, are of an Eel-like Figure, it might be very easy (by supposing them both the same) to form plausible Conjectures concerning the Production of *Eels in Paste*, a Particular which at present seems so difficult to be accounted for: but as Truth ought to be the only Object of our Enquiries, I think myself obliged to shew wherein they differ, lest others, who may not have the Opportunities or take the same Pains to examine them, should possibly be misled into such Mistakes by their being somewhat alike.

It is evident at first Sight, on their being viewed and compared together, that the *Anguillæ* of *blighted Wheat* are in general longer and a great deal slenderer than those in *Paste*, that their Motions are also much slower, less vigorous, and more diversified: not incessantly wriggling the Head and Tail, as the *Paste-Anguillæ* do, but lying sometimes motionless, and coiling themselves at other Times, more in the Manner of Serpents than Eels. They are also more transparent, and especially for some Length from the two Extremities; but the most distinguishing Mark of all, is a very clear Part about the Middle of their Bodies, which approaches to an oval Figure when viewed in some Directions, tho' it more frequently appears tri-

angular, from its being presented Side-ways to the Eye.

A B (*Plate X. N° X.*) represent a couple of these *Anguillæ*. The Figure B shews how they lie extended, when they first are taken out from the Grain, and separate in a Drop of Water, either before they begin to move, or when they are really dead.

A. represents one of them alive and vigorous, and endeavours to shew the Manner of its moving. The transparent triangular Spot is pointed out in both *o o*.

C H A P. V.

Of the *PROTEUS*.

NONE, of the many different Animalcules I have yet examined by the Microscope, has ever afforded me half the Pleasure, Perplexity, and Surprize, as that I am going to describe at present: whose Ability of assuming different Shapes, and those so little resembling one another, that nobody (without actually seeing its Transformation performed under the Eye) would believe it to be the same Creature, has given me reason to distinguish it by the Name of the *Proteus*.

When Water, wherein any Sorts of Vegetables

getables have been infused, or Animals preserved, has stood quietly for some Days or Weeks, in any Glass, or other Vessel, a slimy Substance will be collected about the Sides; some whereof being taken up with the Point of a Penknife, placed on a slip of Glass, in a Drop of Water, and looked at through the Microscope, will be found to harbour several Kinds of little Animals that are seldom seen swimming about at large. The Insect we are treating of is one of these; and was discovered in such Slime-like Matter, taken from the Side of a Glass Jar, in which small Fishes, Water-snails, and other Creatures had been kept alive two or three Months, by giving them fresh Water frequently; though the Sides of the Jar had seldom or never been wiped or cleaned.

Having one Evening been examining a little of this Slime, which I found plentifully stocked with several Kinds and Sizes of Animalcules that were to me no Strangers, such as *Bell-Animals*, *Wheel-Animals*, *Funnel-Animals*, and others whereto as yet no Names are given; I was diverted with the sudden Appearance of a little Creature whose Figure was intirely new to me, moving about with great Agility, and having so much seeming Intention in all its Motions, that my Eyes were immediately fixed upon it with Admiration. Its Body

in Substance and Colour resembled a Snail's: the shape thereof was somewhat elliptical, but pointed at one End, whilst from the other a long, slender, and finely proportioned Neck stretched itself out, and was terminated with what I judged to be an Head, of a Size perfectly suitable to the other Parts of the Animal. In short, without the least of Fancy, which is ever carefully to be guarded against in the Use of the Microscope, the Head and Neck and indeed the whole Appearance of the Animal had no little resemblance to that of a Swan; with this Difference however, that its Neck was never raised above the Water, as the Neck of a Swan is, but extended forwards, or moved from Side to Side, either upon the Surface of the Water, or in a Plane nearly parallel to the Surface thereof.

N^o XI. *Plate X.* 1. is an exact Representation of this extraordinary Animal the first Time I ever saw it.

Its Size was about equal to that of the *Wheel-Animal*; whose general Form may be distinguished well enough by the *fourth Glass* of Mr. *Cuff's Microscope*, though the *first* is necessary to form a Judgment of its several Parts. It swam to and fro with great Vivacity, but stopped now and then for a Minute or two, during which Time its long Neck was usually employed, as far as it could reach, forwards, and on every
Side,

Side, with a somewhat slow but equable Motion, like that of a Snake, frequently extending thrice the Length of its Body, and seemingly in search of Food. *Fig. 2.* attempts to shew it as thus described, but is unable to express the curious Turn and Elegance of its Shape.

I could discern no Eyes, nor any Opening like a Mouth in what appears to be the Head; but its Actions plainly prove it an Animal that can see; for notwithstanding Multitudes of different Animalcules were swimming about in the same Water, and its own progressive Motion was very swift, it never struck against any of them, but directed its Course between them, with a Dexterity wholly unaccountable, should we suppose it destitute of Sight.

This Creature seemed to me so extraordinary, I could not forbear calling all my Family to see it. And after having viewed it by the *fourth Magnifier*, that being the Glass I was using when I first discovered it, we were very desirous to examine it more strictly by enlarging it still more. Being therefore obliged to shift the Glass, which took up some little Time, I lost my Animal as unaccountably as I had found it; all the Search I could make, for Half an Hour at least, being unable to discover any thing bearing the least Resemblance to it: tho' I replaced the Glass

I had employed before, and carefully travelled over the whole Drop a great Number of Times. All I found remarkable therein, but which I regarded very little, was a pretty large Animalcule, that I remembered to have seen before what I was now seeking for had presented itself to View, and whose Appearance was as at *fig. 3.* In a Word, after much Pains to no manner of purpose, concluding my new Acquaintance irrecoverably lost, though I could not conceive how; I put the Microscope aside, very much disappointed and dissatisfied.

A Fortnight or three Weeks after, examining some more of the same slimy Matter, I was again surprized and pleased with another of these Animals, that started up under my Eye, and swam about as the former had done: but the Water it was in beginning to dry away, and being employed a few Moments in adding a fresh Supply, I lost it as strangely as I had done before, and looked for it again to as little purpose, till my Patience was wearied out.

Frequently, after this, I examined the same Matter, in hopes of finding some of these little Creatures, but all my Endeavours proved fruitless; and therefore, as I could give no better Account of them, I determined not to mention them at all. But one Night, shewing some other Animalcules in the beforementioned Slime, to my ingenious
Friend

Friend Mr. *Turberville Needham*, (whose long Acquaintance with the Microscope has made him equal at least to any body in the Knowledge and Use thereof,) we fortunately and unexpectedly discovered one of these, and resolved to watch it carefully by turns, and satisfy ourselves concerning it as far as possible. Nor indeed were our Precautions need^d less; for when it had been swimming about a considerable while (in the Postures represented by *fig. 1* and *2*,) we beheld it on a sudden draw in its Neck and Head in the Manner that a Snail does, so that both of them disappeared intirely: its Body became then more opake, was shaped as *fig. 3*. and moved about very slowly with the large End foremost.

I was now sufficiently convinced how I had been before deceived by the Animal's disappearing in one Shape, and appearing in another so extremely different. The Discovery we had made rendered us more eager to discover farther, and determined us not to leave it till it should re-assume its former Shape. But we were still more surprized, when, instead of so doing, we saw a Kind of Head (though quite unlike what it had before) thrusting itself out a little way; which new Head soon appeared furnished with a *Wheel-like* Piece of Machinery, the quick Motions whereof drew a Current of Water to it from a considerable Distance. The Animal in this Posture is shewn *fig. 4*.
Having

Having often pulled in and thrust out this short Head, sometimes with and sometimes without the *Wheel-work*, the Creature, as if weary, remained motionless for a while, and then very slowly protruded its long Neck under its own Body, as at *fig. 5*; soon after which it swam backwards and forwards extending its Neck, and turning it about every way with wonderful Agility, as if in search of Prey. Twice or thrice it altered the Form of its Body, and disposed its long Neck in the Manner of *fig. 6*.

Being now without Fear of losing our Object, we changed our Glasses several times, and continued our Observations till we were fully satisfied of its Transformation; and the *Figures* herewith given were taken by my Son, (who has been much used to make Drawings from the Microscope) during this Examination.

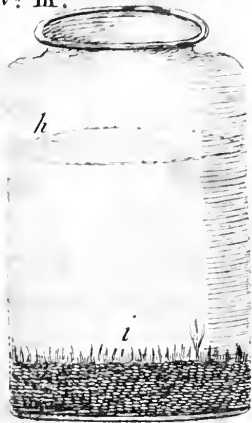
C H A P. VI.

Of the WHEELER, or Wheel Animal.

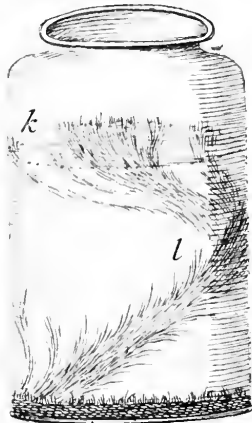
THE *Royal Society* having been pleased to accept very favourably a Description of this little Creature, addressed to *Martin Folkes, Esq;* their worthy President; as I find no Reason since that time for altering any Part thereof, I shall give it here in the same Form and Words.

Animalcules.

N^o III.



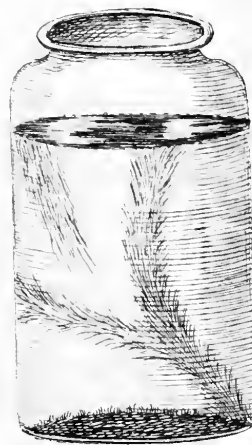
N^o IV.



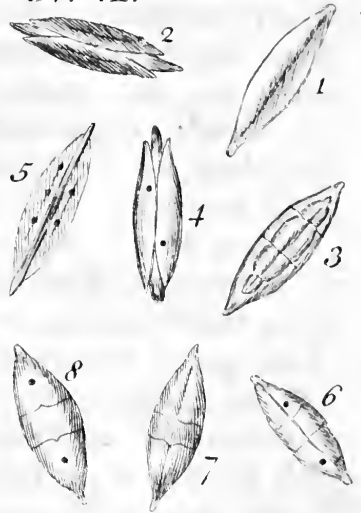
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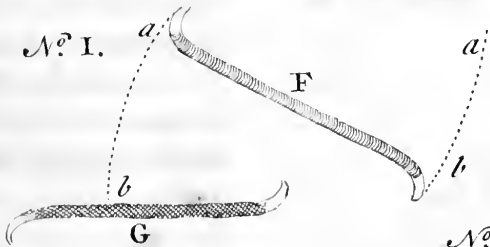
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N^o VII.



N^o I.



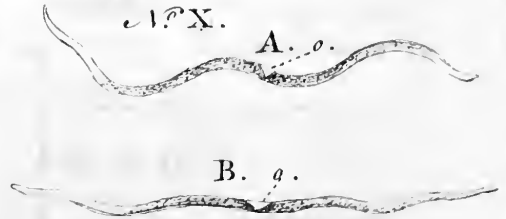
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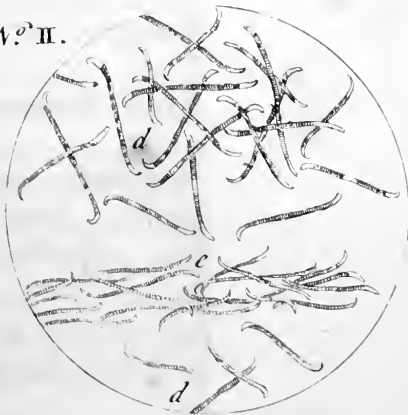
N^o VIII.



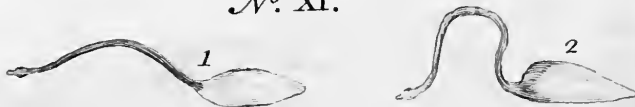
N^o X.



N^o II.



N^o XI.



My dear Sir,
I have the honor to acknowledge the receipt of your letter of the 14th inst. in relation to the execution of the late Act of Parliament, and in answer to inform you that the same has been forwarded to the proper authorities for their consideration.

I am, Sir, very respectfully,
Your obedient servant,
John Bull

TO

MARTIN FOLKES, Esq;

President of the *Royal Society*.

London, January 16th 1744-5:

S I R,

I Take the Liberty to lay before you the best Account my Observations can at present furnish out, concerning that wonderful Water Insect the *Wheel Animal*, which you and several other of my curious Friends belonging to the *Royal Society* have often done me the Honour to examine by my Glasses, and admire along with me: and as it is extremely difficult to convey by Words only any true Idea of a Creature so very extraordinary, I have added exact *Drawings* of its different Forms, Postures, and Appearances; in hope, by that Means, of being understood by those who have never seen the Subject, as well as approved of by those that have: in Case you shall judge these Lines worthy to appear where you preside.

This wonderful little Insect is found in Rain Water, that has stood some Days in Leaden Gutters, or in Hollows of Lead on the Tops of Houses, or in the Slime or Sediment

diment left by such Rain Water ; and if carefully sought after may be found also in other Places. Mr. *Leeuwenhoek*, that diligent Searcher into Nature, was the first Discoverer of it about fifty Years ago, (*viz.* in the Year 1702) soon after which he communicated an Account and Drawing thereof to the *Royal Society*: both which may be seen in the 295th Num. of the *Philosophical Transactions*. What Regard was then paid to this curious Discovery I am wholly ignorant, but probably it was looked upon as a Matter of great Difficulty to find the Animal, and for that Reason little or no Enquiry was made after it, by the few who then amused themselves with *Microscopes* : however, from that Time till within these few Years (that People have begun to think the Works of their Creator, however minute, not unworthy of their Notice,) I question very much whether it has ever been seen by any one in *England*.

In order, therefore, to gratify the *laudable Curiosity* which at present diffuses itself amongst us, and seems the happy Omen of great Improvements in the Knowledge of Nature, I have not only shewn this amazing Animal to Numbers of Gentlemen at my own Home, but having by the Assistance of a more convenient *Microscope* for the Purpose than Mr. *Leeuwenhoek* probably was Master of, examined it with the strictest Attention, under

der all its various Appearances, and made several Observations thereon more than he has left us, the same Motive induces me to give the best Account thereof I can.

I call it a *Water Animal*, because its Appearance as a living Creature is only in that Element. I give it also for Distinction sake the Name of *Wheeler*, *Wheel Insect* or *Animal*; from its being furnished with a pair of Instruments, which in Figure and Motion appear much to resemble Wheels. It can, however, continue many Months out of Water, and dry as Dust; in which Condition its Shape is globular, its Bigness exceeds not a Grain of Sand, and no Signs of Life appear. Notwithstanding, being put into Water, in the Space of Half an Hour a languid Motion begins, the Globule turns itself about, lengthens by slow Degrees, becomes in the Form of a *lively Maggot*, and most commonly in a few Minutes afterwards puts out its Wheels, and swims vigorously through the Water in search of Food; or else, fixing by its Tail, works them in such a Manner as to bring its Food to it. But sometimes it will remain a long while in the Maggot Form, and not shew its Wheels at all. ----- The Drawings represent these different Changes; and I hope to shew how they are performed.

If the Water standing in Gutters of Lead, or the slimy Sediment it leaves behind, has any thing of a red Colour, one may be almost certain

certain of finding them therein * : and, if in Summer, when all the Water is dried away, and nothing but Dust remains, that Dust appears red, or of a dark brown, one shall seldom fail, on putting it into Water, to discover Multitudes of minute reddish Globules, which are indeed the Animals, and will soon change their Appearance, in the Manner just now mentioned.

The Minuteness of these Animals makes it almost impossible to know whether you have them in the Water or not, without examining it by Glasses: the same Minuteness renders it also impracticable to separate them from the Dirt or Slime found along with them, and on which perhaps they feed : in short, they are intirely *microscopical Insects*, and whatever is said concerning them must be understood to imply, as under Inspection by the first or second Magnifier of the Double Microscope.

My Way of discovering them is, by placing a small Drop of the Water, wherein I know they are, with some of the Sediment therein, under the third or fourth Magnifier ;

* *Wheel Animals*, though found with most Certainty in Leaden Gutters, &c. are often discovered in the Waters of some Ditches, and likewise in Water that has stood a considerable Time even in the House : for I have often met with them, in sufficient Plenty, in a Sort of slimy Matter, that is apt to be produced on the Sides of Glasses and other Vessels, that are kept long with the *Infusions of Hay* or other *Vegetables* ; and probably they are wasted thither by the Air, when in the Condition of little dry Globules.

fer ; and, when I have thereby found them, I change the Glafs for one that fhews them larger, and then watch all their Motions with great Attention.

This little Creature fhews itfelf at firft (unlefs it be in its Globule Form) like a transparent Maggot or Caterpillar, and appears lengthening out its Body confiderably at fome times, and at others contracting it as much. Its Motion from Place to Place is likewise then performed in the Manner of fuch Infefts, fixing firft its Tail and extending its whole Body, then faftening its Head and drawing up its Tail to it : fo that by fixing its Tail and pushing its Body forwards, faftening its Head and drawing its Tail thereto, alternately, it works itfelf along pretty nimbly. *Vid. fig. 1, 2. Plate XI.*

But one fhall often behold it changing this Appearance in an Instant, and affuming a Form extremely different ; for its Snout being pulled fomewhat inward, the anterior End becomes clubbed, and immediately dividing, exhibits, moft furprizingly, to view, a Couple of femi-circular Inftuments, before unfeen, round the Edges whereof many little *Fibrillæ* move themfelves very briskly, fometimes with a kind of Rotation, and fometimes in a trembling or vibrating manner. An Opening or Mouth alfo appears in the Middle between thefe two Semi-circles. When in

this Condition, the Animal is often seen to unfasten its Tail, and swim along with a great deal of Swiftnefs, seemingly in pursuit of Prey. *Vid. fig. 3.*

The Substance of this Animal seems to be chiefly muscular, every Part thereof being capable of great Distention and Contraction. It has likewise a considerable Degree of Transparency, whereby the Systole and Diastole of its Heart, and the peristaltic Motion of the Intestines, are rendered plainly visible: and a kind of Undulation may be perceived every where within it. It appears strong and vigorous in proportion to its Size, and seems almost continually hunting after minute Animalcules or other little Bodies wherewith the Waters abound.

Fig. 1. shews the Form of the Insect under Examination, when it appears like a Worm or Maggot, and fully extends its Body. Sometimes in this Condition little *Spiculæ* appear darted out at the Head End, with a Sort of vibrating Motion; the Snout is also sometimes more flat, and sharper at other Times, than represented here.

Fig. 2. describes the Manner of its moving from Place to Place whilst in the Maggot Form, by bringing the Head and Tail nearly together; then stretching the Body out, fixing the
Head

Head down, and drawing up the Tail to it.

Fig. 3. exhibits the Insect with its two semi-circular Parts put out, and exactly in the Posture it places itself, when it prepares either to swim away, or to fasten by the Tail and work its Wheels about.

The general Account already given, will 'tis hoped render my Task the easier, now I come to examine the most distinguishing Parts of this Animal; *viz.* the *Head*, the *Thorax* or *Breast*, the *Abdomen* or *Belly*, and the *Tail*: each whereof I shall describe with all the Perspicuity and Brevity the Subject will allow.

The Fashion and Constructure of the Head is wonderful, and extremely different from that of any other Creature hitherto described; its sudden Change out of one Form into another is also unusual and surprizing: for, from being perfectly tapering, and ending almost in a sharp Point, like the Head of a common Maggot, it becomes on a sudden as wide as any Part of the whole Insect, opens a large Mouth, and is furnished by Nature with an amazing Piece of Machinery whereby to procure its Food.

One of these Animals, with the Head as here described, is represented *fig. 4*, where a couple of circular Bodies, armed with small Teeth like those of the Balance-Wheel

of a Watch, appear projecting forwards beyond the Head, and extending sideways somewhat wider than the Diameter thereof. They have very much the Similitude of Wheels, and seem to turn round with a considerable Degree of Velocity, by which means a pretty rapid Current of Water is brought from a great Distance to the very Mouth of the Creature, who is thereby supplied with many little Animalcules and various Particles of Matter that the Waters are furnished with.

As these *Wheels* (for so from their Appearance I shall beg leave to call them) are every where excessively transparent, except about their circular Rim or Edge on which the Cogs or Teeth appear, it is very difficult to determine by what Contrivance they are turned about, or what their real Figure is, though they seem exactly to resemble Wheels moving round upon an Axis.

It is also hardly possible to be certain whether these circular Bodies, round the Edges of which the Teeth are placed, are of a flat Form, or hollow and of a conic Figure. But they appear rather to be the latter, and if so they may be likened, not improperly, to a couple of small Funnels with Teeth set round their large ends. However, be they flat or hollow, they seem plainly to be protruded from a Pair of tubular Cases, into which they can be again re-

tracted at the Will and Pleasure of the Animal; and their Use undoubtedly is to procure it Food, by means of that *Current* or *Vortex* which the Motion of them excites. They turn not always in the same Manner, nor with equal Swiftneſs, neither is the Appearance of their Teeth or Notches conſtantly the ſame: for one ſhall ſometimes ſee them moving in contrary Directions, and ſometimes turning both the ſame Way. It is alſo not unuſual, after they have been moving one Way for a conſiderable Time, to behold them ſtop on a ſudden and turn directly contrarywiſe. Their ſeeming Rotation is ſometimes very faſt, and at other times very ſlow; increaſing or decreaſing ſometimes gradually, and ſometimes all at once.

The Teeth or Cogs of the Wheels ſeem to ſtand very regularly at equal Diſtances: but the Figure of them varies according to their Poſition, the Degree of their Protruſion, and perhaps the Will of the Animal. They appear ſometimes like minute oblong Squares riſing at right Angles from the Periphery of a Circle, like ancient Battlements on a round Tower; at other Times they terminate in ſharp Points, and all together reſemble a Kind of Gothic Crown. They are often ſeen in a curvular Direction, all bending the ſame Way, and ſeeming like ſo many Hooks: and now and then one ſhall

the Ends of them to be clubbed, or in Appearance like a Number of little Mallets. This Figure, and the first, they however assume but rarely.

When the Forepart of this Creature first appears to open or divide, the Parts above described, which when fully protruded resemble Wheels, and seem to have a quick Rotation, coming then but a little Way beyond their tubular Cases, (and being in that Condition like round Pieces of Paper folded in the Middle, or Funnels whose Sides are flatted almost together,) seem only like a couple of semi-circular Parts, about the Edges whereof, what are seen afterwards like the Teeth of the Wheels, appear only as little *Fibrillæ* or *Spiculæ*, having all a nimble and continual vibrating Motion upwards and downwards, whereby the Water becomes greatly agitated, and brought to the Animal from several times the Distance of its own Length. *Vid. fig. 3.* *

Before it begins to shew itself in this Posture, it frequently fastens its Tail to the slimy dirty Matter found with it in the Water, or else to the Glass whereon it is placed for View; and buoying up its Body in the Water,
pushes

* This *Vibration* commencing commonly some time before the *Wheel-Work* pushes out and exerts its *rotatory Motion*, some People, not overstock'd with Patience, have concluded, that it has no other Motion, than such a *Vibration* of the *Fibrillæ*; but I am perswaded a little more Attention will convince them of their Mistake.

pushes its Head forwards, directing it this Way and that Way with a great deal of Agility, and seemingly in search of Food. In the mean while, many minute Animalcules and other little Bodies are drawn along with a rapid Current of Water, some whereof are taken in and swallowed, and others rejected, though brought to the Opening of its Mouth, which appears exactly in the Middle, between the two above described Semi-circles.

While the Sides of the Wheels are thus doubled as it were together, there is little or no Appearance of any circular Motion, the *Fibrillæ* about their Edges seeming to have only a quick Vibration : but most commonly, after two or three Minutes, this extraordinary Apparatus becomes protruded farther, the two semicircles push out, and open at the same Time, each of them immediately resembles a compleat Circle or Wheel, seems to turn round very regularly, and its little *Fibrillæ* appear changed into Cogs or Teeth, in the Manner abovementioned.

As the Animal is capable of thrusting these Parts out, or drawing them in, somewhat in the Way that Snails do their Horns, the Figure of them is different in their several Degrees of Extension and Contraction, or according to their Position to the Eye of the Observer, whereby they not only appear in all the various Forms before represented, but seem at certain Times as if the circular Rim

of the Wheel or Funnel were of some Thickness, and had two Rows of Cogs or Teeth, one above and the other below that Rim.

When the Wheels appear in Motion, the Head seems large in proportion to the Size of the Animal; and tho' it is then every where transparent, a Ring or Circle, more particularly remarkable for its Clearness, may commonly be perceived about the Middle of the Forehead, a little above the Mouth. (*See Figure 5. a.*) I shall not pretend to call this the Seat of the Brain, thought its Situation and Appearance would perhaps justify such a Supposition; but as I am fully sensible how very easy it is for me to be mistaken, I am extremely fearful of leading others into Mistakes. Many Vessels which seem to take their Origin from hence are discernable in the Head, wherein some transparent Fluid appears continually agitated with a Sort of fluctuating Motion. All these Vessels and every Part of the Head are capable of great Distension and Contraction, and frequently alter their Figure.

The Thorax or Breast *b*, is joyned to the Head by the Interposition of a short annular Circle or Neck *c*, which is very plainly distinguished when the Insect is stretched out, and is working with its Wheels. This Thorax is nearly one sixth Part of the whole Animal, and deserves the most

most careful Examination ; for as the Heart *d* may be seen therein more distinctly, its Figure and Motions may consequently be observed much better in this than in any other small Creature I have met with.

The Heart *d* is placed almost in the Middle of the Thorax, where its Systole and Diastole can't fail to catch the Eye of every attentive Observer ; for it is seen through the Back of the Insect very plainly, shutting and opening, alternately, with great Regularity and Exactness. Its Size is proportionable to the Creature's Bigness, and its Shape during the Systole or Time of Contraction is nearly circular, being composed seemingly of two semi-lunar Parts which then approach each other, laterally, and form between them a roundish or Horseshoe-like Figure, whose upper Side is flat, but the under one convex. The Diastole is performed by a seeming Separation or opening of these two semi-lunar Parts, whereby the transverse Diameter of the Heart is very much enlarged. This Separation begins exactly in the Middle of the lower Part next the Tail, and opens to such a considerable Width upwards, that the two Parts when at their utmost Distension seem only joyned by an arched Vessel at their anterior End. The alternate Motions of Contraction and Dilatation are performed with great Strength and Vigour, in pretty

much the same Time as the Pulsations in the Arteries of a Man in Health ; as I have often proved by feeling my own Pulse whilst I have been viewing them. In each of the semi-lunar Parts there appears a Cavity, which seems to close when those Parts come together, and to open itself again when they separate.

The Motions of the Heart are communicated to all the other internal Parts of the *Thorax* ; and indeed seem to extend a great deal farther ; for a strict Examination discovers, at the same Time, throughout the whole Animal, Contractions and Dilatations going on that are apparently correspondent thereto.

It is however necessary to remark, that these Motions of the Heart are, sometimes, as it were suspended, or unperceivable for two or three Minutes, after which they become renewed, and go on again with the same Vigour and Regularity as before. And this Suspension of the Systole and Diastole, has made some Gentlemen to whom I have shewn it, doubtful, whether the Part we have been describing can therefore be the Heart. But their Doubt arises wholly from a Supposition that the Hearts of minute Insects must continue beating with the same Constancy, and be subject to the same Laws as the Hearts of the larger Kinds of Animals, which probably is not the Case.

The

The Situation, the Size, the Contraction and Dilatation of the Part we suppose to be the Heart, all concur in Support of that Opinion; but they can hardly all agree with any other of the Viscera: and as to the Suspension of its Motion, since in the Tortoise, the Viper, the Frog, and perhaps many other Creatures who become torpid at some Seasons, the Motion of the Heart is suspended or unperceivable for a considerable Length of Time, there is no Absurdity in believing that the same thing may happen to this Insect, which is some times in a torpid or inactive State as well as they, without doing it any Injury. Nay, that the Motion of its Heart (whether this Part be it or no) must unavoidably be suspended, whilst this very Animal is contracted into a Ball, and as dry as Dust, is I think highly probable.

The Blood or circulating Fluid is so absolutely colourless in this Creature, that the Current of it through the Vessels is undistinguishable by Glasses, however likely it may seem, from the strong Contraction of the Heart, that a Circulation must be carried on, and that too very briskly. One sees indeed almost every where a sort of irregular Agitation of some Fluid, which may be perhaps the compound Motion of Currents running different Ways and forming such an
Appear-

Appearance, though no one single Current is any where distinctly visible.

From the under Part of the Thorax a small transparent Horn proceeds, which can be never seen unless the Insect turns on its Back or Side. I know not whether it be a Distinction of Sex, or to what other Purpose it may serve; for these minute Animals cannot possibly be so managed as to bring it under Examination when one pleases; and as it is only seen sometimes by Accident, I cannot pretend to say whether all or some of them only are furnished therewith. It is shewn in the *Figures* 1 and 2. *a a.* being more commonly seen when the Creature is in the Maggot Shape than at other Times.

Immediately below the Thorax is another annular Circle or Division *b*, joyning upwards to the Thorax, and downwards to the Abdomen; the Entrance whereof it serves occasionally to enlarge or diminish. This is shewn *fig. 5.* at the Letter *e.*

The Abdomen or Belly *f* is much the largest Part of the Animal, and contains the Stomach and Guts. When the Insect is full of Food these Bowels appear opaque and of a Blood-red or Crimson Colour, extending in Length from the Thorax quite through the Belly and great Part of the Tail, and exhibiting a fine View of the peristaltic Motion, or such gradual Contractions and Dilatations as seem intended to propel
their

their Contents downwards. Around the Bowels are many Ramifications of Vessels both longitudinal and transverse; and between the Bowels and the Skin a Fluid exceedingly transparent fluctuates in a Manner Words cannot describe.

The Belly is capable of stretching out greatly in Length, or being shortened very much and widening its Diameter: in short it assumes many Shapes, and becomes, on Occasion, a Case including the whole Animal, as will by and by be shewn.

From a Joynt at the lower Part of the Belly to the posterior Extremity is what I call the Tail. (*Vid. fig. 5. g.*) It has three other Joynts, to the lowermost whereof the Bowels extend themselves, and appear contracting and dilating upwards and downwards, though not so remarkably when they are empty as full. This Part runs tapering from the Belly to its End, and is lengthened or shortened at the Creature's Will. When it is inclined to fix itself by the Tail to any thing, (as commonly is its Way when it intends to work with its Wheels,) two, four, and sometimes six little transparent Hooks or Fins may be seen thrust out at its End, and serving for that purpose. They are placed in Pairs: one Pair is at the very Extremity, and the other two a little Way up the Sides: but the three Pair are seldom seen together.

Tho'

Tho' this Insect swims very swiftly, and, seemingly with great Ease, neither Legs nor Fins can be perceived to assist it in so doing, unless those just now mentioned about the Tail, and the Horn under the Breast may be imagin'd such. Wherefore since the Wheels in its Head are always set to work very briskly whenever it begins to swim, one may reasonably presume they are the Instruments by which it performs this Office. And, indeed, looking at the Manner of its swimming through a Hand Magnifier, when it is at large in a Phial of Water, will confirm this Opinion greatly; for there one shall often discern it rising in a perpendicular Direction, and by the Rotation of its Wheels climbing as it were upwards and mounting through the Water; but sinking down again instantly upon the ceasing of their Motion.

As I call these Parts *Wheels*, I also term the Motion of them a *Rotation*, because it has exactly the Appearance of being such. But some Gentlemen have imagined there may be a Deception in the Case, and that they do not really turn round, though indeed they seem to do so. The Doubt of these Gentlemen arises from the Difficulty they find, in conceiving how, or in what Manner, a Wheel, or any other Form, as Part of a living Animal, can possibly turn upon an Axis, supposed to be another Part
of

of the same living Animal ; since the Wheel must be a Part absolutely distinct and separate from the Axis whereon it turns ; and then, say they, how can this living Wheel be nourished, as there cannot be any Vessels of Communication between that and the Part it goes round upon, and which it must be separate and distinct from ?

To this I can only answer, that place the Object in whatever Light or Manner you please, when the Wheels are fully protruded they never fail to shew all the visible Marks imaginable of a regular turning round, which I think no less difficult to account for, if they do not really do so. Nay, in some Positions, you may with your Eye follow the same Cogs or Teeth whilst they seem to make a compleat Revolution ; for, the other Parts of the Insect being very transparent, they are easily distinguished through it. As for the Machinery, I shall only say, that no true Judgment can be formed of the Structure and Parts of minute Insects by imaginary Comparisons between them and larger Animals, to which they bear not the least Similitude. However, as a Man can move his Arms or his Legs, circularly, as long and as often as he pleases, by the Articulation of a Ball and Socket, may there not possibly be some Sort of Articulation in this Creature whereby

whereby its Wheels or Funnels are enabled to turn themselves quite round?*

Having described the most remarkable Parts of this Insect, I shall by the four following Figures endeavour to represent some other of the most usual Forms it assumes, both when its Wheels are fully protruded, and when the Edges only of them are shewn with their little vibrating *Fibrillæ*.

Fig. 6. is the *Wheel Insect* raising itself on the Tail, stooping the Head downwards, and working its Wheels about. This is a common Posture, in which the Back is bowed, and the Belly appears shortened and distended, great Part of the Thorax being taken into it. The Wheels in this Position seem to turn horizontally, with their Backs upwards and towards the Eye, in which Manner they appear very distinct and large, with their Teeth bending all the same

* It is certain all Appearances are so much on this Side the Question, that I never met with any who did not on seeing it call it a *Rotation*; tho' from a difficulty concerning how it can be effected, some have imagined they might be deceived: Mr. *Leeuwenhoek* also declared them to be *Wheels* that turn round; vid. *Phil. Transf.* No 295. But I shall contend with nobody about this Matter: it is very easy for me I know to be mistaken, and so far possible for others to be so too, that I am perswaded some have mistaken the *Animal itself*, which perhaps they never saw, whilst instead thereof they have been examining one or other of the several *Water-Animalcules* that are furnished with an Apparatus commonly called *Wheels*, tho' they turn not round, but excite a Current by the mere *Vibration* of *Fibrillæ* about their Edges.

same Way, and resembling as many Hooks. The different Parts of the Animal as before described are explained by this Figure.

Fig. 7. shews the Animal turned with its Side towards the Eye, as it frequently presents itself. The Wheels here have the same Appearance as in the preceding Figure; but one of them lies considerably below the other, the whole Body being somewhat twisted, whereby the Horn under the Thorax is distinctly brought to View.

Fig. 8. and *9.* exhibit two of these Creatures in the Postures they are often seen, when the Wheels are not thrust out, but the *Fibrillæ* appear moving up and down with very quick Vibrations. We see particularly in *fig. 9.* the whole Space between these Parts gaping like a wide Mouth, and different from any of the former Figures.

To describe the many Postures I have seen this Creature in would be a Waste of Time; but the Manner of its changing, when it pleases, into a round Globule or Ball, is so remarkable a Part of its History, that I must attempt to give the best Account of it I can; as I have many times observed very attentively every Step in its Metamorphosis,

After

After having turn'd about its Wheels, in various Directions, for two or three Hours, in the Water, and probably fill'd its Belly, (during which Time its Tail remains fastened to some Dirt or Slime, or to the Slip of Glass it is placed upon :) one shall perceive it, by Degrees, moving them with less Vigour, and at last drawing them quite within the Head. The Head and included Wheels sink down then very slowly into the Thorax, the Belly swells, and the whole appears like *fig. 10.*

Soon after, the Thorax also (which now contains the Head and Wheels) is drawn within the Belly, and below the annular Circle at the Top of it, as *fig. 11.* represents.

The said annular Circle then contracts, and its Sides come together like the Sides of a Purse when the Strings are pulled, closing over the Head and Thorax, which, now, filling the upper Part of the Belly make it nearly round, like *fig. 12.*

In the last Place, the three upper Joynts of the Tail come down over the lower Joynt which remains fixt ; immediately the Belly also sinks, or is pulled down, and incloses the whole Tail. All the Parts being now included in the Belly, which becomes their Case or Covering, it swells into a round Ball, lies without any Motion, and appears considerably opake. (*Vid. fig. 13.*) It still adheres however by the Tail. All

The Wheel Animal in its several Postures

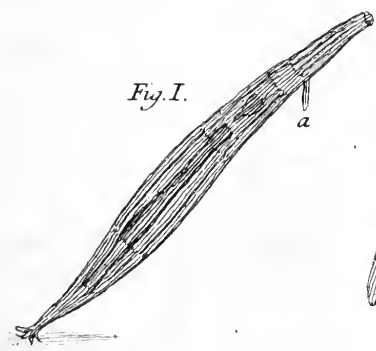


Fig. I.

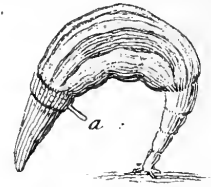


Fig. II.



Fig. III.



Fig. IV.

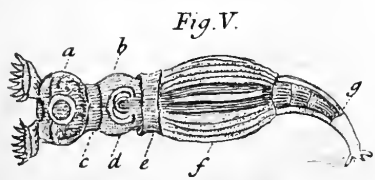


Fig. V.



Fig. VI.



Fig. X.



Fig. XI.



Fig. VII.



Fig. VIII.



Fig. IX.



Fig. XIII.



Fig. XIV.



Fig. XII.

...the Head and all together without
...the Body in the Mass

...the Body in the Mass
...the Body in the Mass

...the Body in the Mass
...the Body in the Mass

...the Body in the Mass
...the Body in the Mass

...the Body in the Mass
...the Body in the Mass

...the Body in the Mass
...the Body in the Mass

...the Body in the Mass
...the Body in the Mass

Sometimes, when in the Maggot Form, it rolls its Head and Tail together, without drawing them into its Body; in the Manner of *fig. 14*.

All my Endeavours have been hitherto unable to discover how these Creatures propagate, though for three Years past I have never been without them, and am continually sensible of their Increase, by observing Numbers of extremely small ones appearing from time to time: which undoubtedly are young Fry. There's however good Reason to believe they proceed from Eggs: for I have often seen, in the Water along with them, Parcels of Ova, gelatinous like the Spawn of Frogs, and of a Size proportionable to the *Wheel Animal*. -- But after whatever Manner they are propagated, 'tis pretty certain, from the exceeding Minuteness of some in Comparison of others, that they come out at first in their perfect Shape, and are not the *Nymphæ* of any other Insect, as many Creatures found in the Waters are.

Mine have constantly been kept in the same Glass Vessel, sometimes with and sometimes without Water: for as the Sides of the Glass were often left dry, I have suffered those that had fastened themselves there to remain some Months in that Condition: nevertheless, I always found them to become as lively as ever on giving them fresh Water. Mr. *Leeuwenhoek* kept some Dirt, taken out of a Leaden Gutter, and dried as hard as

Clay, for twenty-one Months together ; and yet when it was infused in Water, Multitudes of these Creatures soon appeared unfolding themselves, and quickly after began to put out their Wheels : and I myself have experienced the same with some that had been kept much longer.

All their Actions seem to imply Sagacity and Quickness of Sensation. At the least Touch or Motion in the Water they instantly draw in their Wheels. Notwithstanding their Smallness, one sees several Species of Animalcules swimming in the Water with them, compared to which themselves appear like Whales. These Animalcules are their Prey : which they take either by Pursuit, or draw to them by the Current of Water which their Wheels excites.

It has constantly been my Endeavour to discover the Eyes of this Creature, but I have never been able to discern that it has any. And yet, when one beholds it swimming along with great Swiftnes, turning its Head on every Side, and seemingly pursuing its Prey, avoiding any Dirt or other Matters in the Water that would obstruct its Passage, and directing its Course with as much seeming Care, Choice, and Conduct as Animals that have Eyes do, one can hardly think it destitute of Sight.

I would industriously avoid giving Way to Fancy in Cases of this Nature, but must
acknow-

acknowledge my suspecting that it has Eyes somewhere within its Wheels: and my Reasons for this Suspicion are, its blundering, irregular, and slow Motions while it appears in the Form of a Maggot, before its Wheels are put out, and the Regularity, Swiftnes, and steady Direction of its Motions afterwards: whereto I might add, that when it swims along its Wheels are always out. Besides, all the Creatures we know that move themselves from Place to Place with Swiftnes, either by running, flight, or swimming, are remarkable for their keenness of Sight; and indeed it seems probable that the same Rule may hold through all the Animal Creation: for, as the Gifts of Providence are ever suited to the Exigencies of its Creatures, and contrived in the best manner for their Preservation, we can scarcely imagine Swiftnes is bestowed on any without the additional Blessing of Sight to direct its Course; since the former without the latter must unavoidably precipitate the Creature into continual Danger of Destruction. — This makes me suppose it may possibly have Organs of Sight somewhere about the Wheels: nor is there any thing more extraordinary in that than in the Eyes of Snails, which are generally allowed to be placed at the Extremities of their Horns, and consequently must be thrust out and drawn in with them.

I cannot conclude this Subject without doing all the Honour I am able to the Me-

mory of Mr. *Leeuwenhoek*, by repeating, that we are obliged to his indefatigable Industry for the first Discovery of this most surprizing Insect.

C H A P. VII.

Different Kinds of WHEEL ANIMALS.

THERE are found in the Waters several other Kinds of Animalcules, furnished with Instruments for making an Eddy, and thereby bringing to themselves such minute Insects, or very small Particles of Matter, as serve them for Food. Among these some appear to have a *rotatory* and others a *vibrating Motion*; some also seem capable of being employed both ways.

In the Ditch-Water sent me from *Norwich*, as before mentioned *pag.* 233. I discovered several *Wheel Animals* with Tails enormously long, but in all other Respects, as far as I could discern, differing not at all from those just now described; the Motion of the Wheels, the Pulsation of the Heart, and the Undulation of the Bowels appearing exactly the same in both: Nothing therefore seems farther necessary than to give the Picture of them, which see *Fig.* 1. *Plate* XII.

Fig. 2 and 3 in the same *Plate*, represent two different Sorts of Animalcules, several whereof were found some Years ago, in
Water

Water taken out of a Leaden Cistern that stood in *Somerjet Garden*. --- The anterior Part in the first of these has a large Opening, surrounded with sharp *Spiculæ a*, and is evidently crustaceous, though the Body and Tail are muscular. It is not easy to discern the Instruments within this Mouth or Opening that serve to form a Current of Water, as the Creature does not thrust them beyond the Neck *b*. When it swims along it seems extremely formidable to the minuter Animalcules, Multitudes of which are frequently sucked in, together with a great deal of Water, which is spouted out again immediately. When the Tail is fastened to something, it turns the Body about and directs its wide Mouth to every Side, and brings a Stream of Water from a considerable Distance. The Motions of the Bowels are distinctly visible in this Animal; and within several of them one may see an opaque oval Body *c*, which by its Size and Appearance I imagine to be an Egg; which if it is, it signifies their Increase to be much less than that of most other minute Animalcules; for I never observed more than a single one in any of them; and indeed I never found the Creatures themselves in very great Number. They are somewhat larger than the common Wheel Animal.

Fig. 3. represents an Animalcule found in the same Water with the former, and resembling it pretty much in the Size and

Shape of its Body, though its Head and Tail are different : for this Creature's Tail is furnished with a Couple of Instruments *a a*, that lie sheathed therein, unless when they are made use of to fasten it to any thing, that it may the better be inabled to occasion an Eddy of Water and bring its Food to it with the Stream. During the Time it is so employed the Body appears extended (as in the Figure) and a Number of *Fibrillæ*, protruded from two projecting Parts *b b* that compose the Head, put the Water into a violent Motion, and excite a Current, by their vigorous and quick Vibrations, which sets directly towards the Mouth *c*.

This little Creature is intirely muscular, and frequently changes the Form of its Appearance by contracting its Body and pulling in its Head or Tail. The peristaltic Motion of its Bowels, which are considerably opake, is seen working upwards and downwards in an odd Manner, but no Part can with any Certainty be known to be either Lungs, Heart, or Stomach. In many of them however, an oval Body, which I guess to be an Egg, is very distinguishable, contained seemingly in a *Uterus*, or Vessel, that separates it from the other Bowels. They lived with me several Days in the Water they were brought in, but I could never be so lucky to see any of these Eggs, (if such they are) discharged from the Animal,

C H A P. VIII.

Animalcules with Shells and Wheels.

IN the Summer of the Year 1745, I first took notice of three Sorts of *Wheel Animals* * having Shells, which I found herding together in the Water of the Cistern in the Garden of *Somerset House*, and have seen since in other Waters. The first of them is represented by the Figures 4, 5, 6: the second Sort by those 7, 8, 9, 10: and the third Sort are marked 11, 12, 13. *Plate XII.*

The first Sort when extended is in Length about twice its Breadth. It is contained in a Shell, whose Fore-part or End is armed with four very long Spikes on one Side of its Rim, the other Side whereof has no Spikes, but is waved or bent in two Places, much like the Form of a Turkish Bow: *vid. fig. 6.* The posterior End has a large circular Hole through which the Tail is put out. By this Tail it fastens itself to any thing it meets with, when it intends to set the Wheel-work at its Head in Motion; but in swimming, and at all other Times when it is not fixed by it, it wags this Tail backwards and forwards as a Dog does his,

U 4

and

* These are called *Wheel Animals*, from their resembling the foregoing in some Particulars.

and makes use of it on other Occasions which we shall presently take notice of.

Its Body seems divided into three Parts, the Head, Thorax, and Abdomen: each whereof is capable of great Distension and Contraction; the Creature being able by extending them all three to protrude its Head beyond the Shell, and on contrary, by contracting them, to draw its whole Body a great Way within the same.

The Head when extended divides into two Branches, between which another Part (a Kind of Proboscis) is pushed out, at whose End are two Fibrils, that appear when at Rest like one very broad Spike, but which it can move very briskly to and from each other with a *vibrating Motion*, bringing thereby a Stream of Water to its Mouth, whose Situation is just betwixt them. And the better to effect this, several of the like *Fibrillæ* are placed on each Side of the Head, which *vibrate* in the same Manner, as do likewise some very small ones at either Corner. All this may be understood by viewing *fig. 4.*

But sometimes it alters the Form of the two Branches, rounding the Ends thereof, and changing the vibrating Motion of its *Fibrillæ* into a Rotation, or at least what seems to be so; at which Time the Head appears as at *fig. 5.*

Immedi

Immediately to the lower Part of the Head the Thorax is joyned, seemingly of a muscular Contexture, and containing within it an Intestine, which by its Motions must be either the Lungs or Heart of the Animal; *see b. fig. 4. and 5.*

A Communication between the Thorax and the Abdomen or Belly is continued by means of a short Vessel *c*, whose alternate Contractions and Dilatations occasion the Abdomen to rise and fall alternately, having at the same time a Sort of peristaltic Motion. Through this Vessel or Gut all the Food the Animal takes in is conveyed directly to the Abdomen, where it becomes digested, and is then discharged by the Anus, which is placed somewhere near the Tail; but we have not yet been able to discover exactly where, for the Fæces are thrown out sometimes at the lower Opening of the Shell, and sometimes they are carryed upwards (between the Shell and the Body of the Animal) and cast out with a considerable Force at the other End, by the Motions of the *Fibrillæ*, which the Animal can employ to form a Current not only towards him but from him.

The Tail has three Joynts, and is cleft or divided at its Extremity, by which means it can the better fasten to any thing. It is seen most commonly issuing through the Hole at the lower End of the Shell, wagging nimbly

bly to and fro, and is made use of in swimming to steer or direct its Course: but when the Water wherein the Animal abides is almost dried away, or when it has a mind to compose itself to rest, it contracts the Head and Fore-part of the Body downwards, and pulls the Tail upwards, in such a Manner that the whole Animal is brought intirely within the Shell: and at such times only the anterior Edges of the Shell, and the Spikes proceeding therefrom, can be fully distinguished, and determined to be as represented *fig. 6*, whose Description was just now given. For the Shell is so extremely transparent that its Terminations cannot be seen when the Insect extends beyond it; but whatever passes within it is as plainly visible as if there was no Shell at all.

Fig. 7, 8, 9, and 10, shew the several Appearances of the second Species of these shelled Animals having Wheels, which differs from the first in some Particulars now to be described.

The Body of this Species consists of three Parts, in like Manner as the other does; only the Thorax and Abdomen are not in this separated by a Gut or intermediate Vessel as they were in that, but are joyned immediately together; and at that Place in the Thorax, where, in the other Species, I have described an Intestine, which I supposed to be either the Lungs or Heart, an Heart is plainly perceived

ceived in this, having a regular Systole and Diastole, and nearly of the same Form and Size with the Heart of the common *Wheeler*, as the *Figures* 7, 8, and 9, are intended to shew at the Place marked *a*.

This Species likewise draws its Head and Tail occasionally within the Shell, as at *fig.* 10 ; and then its Shell appears terminated on its Fore-part by six short Spikes on one Side of the Rim and two on the other, instead of the four long ones wherewith the first Sort is armed : but this does not always protrude its Head like the other, so far out as to cover the Edges of the Shell intirely : sometimes, on the contrary, the Spikes of the Shell are seen beyond the Head, and the *Fibrillæ* mentioned in the former Description appear playing between them, as at *fig.* 7. However the Head very commonly is as at the *Figures* 8 and 9. --- These are the chief Particulars wherein this Animal differs from the former.

As to their Propagation, both Species carry their *Young* in oval *Sacculi* or Integuments, fastened, externally, to the lower Part of their Shells somewhere about the Tail : These *Sacculi* are sometimes opake only at one End and seemingly empty at the other, see *fig.* 5 : Sometimes the Middle Part appears opake with a Transparency all round, like *fig.* 7 ; and much Variety of Darkness and Transparency may be distinguished, according

according to the different Maturity of the Embrios in these Bags.

It is highly entertaining to see a young one burst its Integuments, and gradually force its Way through them: in doing which the Parent is greatly assistant, for by wagging her Tail to and fro, and striking the Shell, Skin, or Covering briskly therewith, the young one's Head Part becomes as it were squeezed forwards into the Water, tho' the Tail cannot so soon be disengaged. In this Condition the young one sets its Wheels a-going, and exerts all its Endeavours, 'till at last it frees itself from Confinement, and swims away, wagging its Tail as the old one had done before it, and leaving the Integument adhering to the Shell of the Parent; who then uses abundance of Contrivances and Efforts to get rid of it, striking against it with her Tail, fixing the End of her Tail thereto and darting her Body forwards, with several other very odd Motions not easy to be described.

A young one almost disengaged from the Shell, being fastened thereto only by the Tail, is shewn *fig. 9, b.* The Subject from whence this Picture was exactly taken, during the Performance of all the Particulars above described, had also another *Embrio c* adhering to its Shell.

These Animals have one, two, three, nay sometimes even four or five of these young ones

ones hanging to them : but they are frequently without any at all, like the Figures 4 and 8.

The third Species of crustaceous Animals with Wheels, shewn *fig.* 11, 12, 13, is remarkably different from the former two in the Shape and Fashion of its Shell, which extends on either Side a curved or hooked Process, that bending towards the Tail, inward, ends in a sharp Point, and is within a fourth as long as the Tail itself.--The Head-Part of the Shell differs also from those before described, in the Order and Disposition of the *Spiculæ*, of which it has four longer and two shorter ones, placed as in *fig.* 13. where by the Body's being contracted and drawn considerably within the Shell, as frequently is the Case, the Top of the Shell is perfectly distinguishable, and its *Spiculæ* plainly seen.

The Tail of this Creature has the like Figure, Articulations and Motions with that of the other Species : and its Body may properly be divided in the same Manner as theirs, though in Shape it appears somewhat different through the Shell, which the Drawings express sufficiently without any particular Description.

From its Head two Arms or Branches are frequently extended, and the circular End of each is furnished with a Border of *Fibrillæ*, seeming at some times to have a very quick
Vibra-

Vibration, and at others a rotatory Motion, occasioning a rapid Current in the Water.

Their Ova are carried at the Tail End, either fastened to the Tail itself, or to the Proceffes of the Shell, as at *fig. 12.* One, two, or three are the Number usually hanging to them; but some, though very few, have four or five. The *Young* burst their Integuments, and are hatched very probably like the Species before described; but having never had the Pleasure of seeing them do so, I can say nothing more to this Part of their Natural History.

CHAP. IX.

The Water-Flea with branched Horns.

A True Figure and Description of this little Creature having never yet been published amongst us, what follows I hope may prove acceptable.

The Name given it by *Swammerdam* of *Pulex aquaticus arborescens*, I chuse to retain here, as expressing aptly enough its Motions and Appearance.---It is found in Reservoirs of Rain Water, in Basons, Ponds, Ditches, &c. where the Water is not often renewed; and that sometimes in such Abundance, as
by

by its red Colour to make the whole Surface of the Water appear like Blood †.

This Animal is crustaceous, being covered with a thin oval Shell in the Manner of a Lobster or Cray-Fish, but with this Difference, that the Shell being open a good part of its Length, the Animal can thereby put out and draw in its Legs and part of the Body when it pleases.

The upper Part of the Shell bears a near Resemblance to the Head of a Bird, having a sharp-pointed Process very much like a Beak or Bill, but intirely fixt and immovable; and the Eye being placed near thereto, in a Situation much corresponding with that of a Bird, adds much to the Resemblance. This Eye seems composed of several small Globules, though not pearly as those of Land Insects, but all contained in one Integument, wherein they appear to be in some Degree moveable. The Animal has two of these Eyes: but as he always lies on one Side when placed in a Drop of Water to be examined by the Microscope, no more than one can then be seen; which induced Mr. *Bradley* to imagine it had only one Eye, and from thence to call it *Monoculus*; but whoever beholds the monstrous Picture that

Writer

† Some Swarms of them are red, and others green; but whether this Difference be owing to their Food, or some other Accident, or whether they are of different Species, I am unable to determine.

Writer has given of this Insect in his Book on the *Works of Nature*, will be little surprized at any of his other Mistakes.

A little below the Eyes, two Horns, which are moveable, are joynd to the Shelly Head; their Infertion being in the Manner of Ball and Socket. Each of these Horns comes out in one single Trunk at first, but divides soon into a Pair of Branches, each Branch having three Joynts. A small Hair Bristle grows out from either of the two first Articulations, and three pretty long ones from the Extremity of the last.

Just beneath the Infertion of these Horns a long kind of Gut runs down almost the Length of the whole Body, where it joyns to a Part which in Shape very much resembles the Toe of a Bird, having a large Claw or Talon at the End thereof. The Creature can move this Part beyond its Shell with a great deal of Force, and by that means, as I apprehend, performs its springing or leaping Motion.

It has eight Legs or Fins besides this, which, when the Creature lyes otherwise still, are nevertheless in a continual and nimble Motion, forming a brisk Current of Water, like that of many other Animals. They are also very serviceable in swimming, and assist in its circular Motion, of which I shall presently speak.

Behind the abovementioned Gut, and as it were detached from the rest of the Body, the Heart is placed, and may be seen dilating and contracting, alternately, with a very regular and distinct Systole and Diastole.

The lower Part of the Shell terminates in a long Spike or Tail, which is without Motion, but thickly set with six Rows of short strong Spines, making its Appearance like the prickly Horn or Snout between the Eyes of Lobsters, Cray-fish, Shrimps, &c.

Swammerdam has very judiciously observed, * (what every body who examines it carefully will discover to be true) that this Animal has three different Kinds of Motion. The first is a smooth and even swimming, whereby it carries itself horizontally along in the Water. The second is a sudden skipping or leaping, much resembling that of a Flea. And the third is, when lying at the Bottom of the Water, it turns its whole Body round as it were on a Center, with a very brisk Rotation, by means of its small Legs or Fins.

As no Creature lives without its Tormentors, this is very much infested by the *Shelled Wheel Animal* already described Page 298, and shewn in the *Plate* with this, *fig.* 7, 8, 9. Both these Insects are in great abundance frequently in the same Water; and when that

* *Hist. Gen. des Insectes*, p. 69, 70.

is the Case, 'tis not uncommon to discover five or six of the *Shelled Wheel Animals* fastened by their Tails to the Shell or Horns of the *Water-Flea*, and causing to it seemingly a vast deal of Uneasiness; nor can they be driven away, or shaken off, by all the Motions and Efforts the Creature makes use of for that Purpose.

C H A P. X.

The Bell-Flower-Animal, or plumed Polype.

I Was first informed of this Creature by my industrious Friend Mr. *William Anderson*, towards the End of the Year 1743, as his Letters shew; and in the Year 1744 it was taken notice of by Mr. *Trembley*, who gave it, in his *Memoires*, the Name of the *Polype a Pannache*, or the *Plumed Polype*. My Friend, who discovered it in his Searches for the *Polype*, called it the *Bell-Flower-Animal*; and after favouring me with his own Observations, sent me some of the Creatures themselves, which living with me several Months, I had sufficient time and Opportunity to examine and consider them. And as there seems some little Difference between those in my keeping, and what Mr. *Trembley* describes, they may possibly be of another Species, tho' of the same Genus.

This

This is one of the many Kinds of Water Animals which live as it were in Societies ; of which some Sorts hang together in Clusters, but can detach themselves at Pleasure ; whilst others again are so intimately joyned and connected together, that no one seems capable of moving or changing Place without affecting the Quiet and Situation of all the rest. But this Creature forms as it were an intermediate Gradation between the other two, dwelling in the same *general Habitation* with others of its own Species, from whence it cannot intirely separate itself ; and yet *therein* it appears perfectly at Liberty to exert its own voluntary Motions, and can either retire into the common Receptacle, or push itself out from thence and expand its curious Members, without interfering with or disturbing its Companions.

They dwell together, from the Number of ten to fifteen, (seldom exceeding the latter or falling short of the former Number) in a filmy Kind of mucilagenous or gelatinous Case ; which out of the Water has no determined Form, appearing like a little Lump of Slime, but when expanded therein, resembles nearly the Figure of a Bell with the Mouth upwards ; and is usually about the Length of half an Inch, and one Quarter of an Inch in Breadth or Diameter. This Case being very transparent, all the Motions of its Inhabitants may be discerned through

it distinctly. It seems divided, internally, into several Apartments, or rather to contain several smaller *Sacculi*, each of which incloses one of these Animals. The Openings at the Tops of these *Sacculi* are but just sufficient to admit the Creature's Head, and a very small Part of its Body, to be thrust out beyond them, the rest remaining always in the Case. The Animal can however when it pleases draw itself intirely down within the Case, which is an Asylum to secure it from its Enemies, (for 'tis not unlikely many of the larger aquatic Insects prey upon it) and a safe and agreeable Retirement wherein to perform the Functions of Digestion, Sleep, and the other necessary Calls of Nature. This Case it can, I say, retire into at Pleasure; and it never fails to do so when any sudden Motion of the Water, or of the Vessel it is in disturbs it: as also when it has seized with its Arms any of the minute Insects which serve for its Food.

The Arms are set round the Head to the Number of forty, having each the Figure of a long *s*, one of whose hooked Ends is fastened to the Head; and all together when expanded compose a Figure somewhat of a *Horse-Shoe* shape, convex on the Side next the Body, but gradually opening and turning outwards, (*see fig. 19 and 20. Plate XII.*) so as to leave a considerable Area within the outer Extremities of the Arms. And when
 thus

thus extended, by giving them a vibrating Motion, the Creature can produce a Current in the Water, which brings the Animalcules, or whatever other minute Bodies are not beyond the Sphere of its Action, with great Velocity to its Mouth, whose Situation is between the Arms: where they are taken in, if liked, or else by a contrary Current, which the Creature can excite, they are carried away again: whilst at the same time other minute Animalcules or Substances, that by lying without side the Inclosure made by the Arms are less subject to the Force of the Stream, are frequently seized by them: for their Sense of Feeling is so exquisite, that on being touched ever so slightly by any such little Body, it is caught immediately and conveyed to the Mouth. However, one may observe the Creature is sometimes disappointed in its Acquisition: for after drawing down one of the Arms suddenly inwards towards the Mouth, it may be perceived slowly extending itself again, without the Creature's retiring into its Case; which it fails not to do on meeting with any thing worth the while.

The Food is conveyed immediately from the Mouth or Opening between the Arms, through a very narrow Neck, into a Passage seemingly correspondent to the Oesophagus in Land Animals; down which it passes into the Stomach, where it remains for some

Time, and then is voided upwards, in small round Pellets, (which at first I imagined to be its Eggs) through a Gut, whose Exit is near the Neck, where it was first taken in.

The Body of this Animal consists of three Parts or Divisions, in the uppermost whereof all the aforementioned Intestines are contained, though they are not to be distinguished when the Creature is hungry ; but after it has eaten they become distended and opaque, and may very plainly be discovered. The other two Divisions (the lowermost of which I take to be fixed to the Bell or outward Case) seem of no other Service than to give the Creature Power of Contraction and Extension.

The Arms seem not able like those of the common *Polype* to contract or shorten themselves ; but instead thereof, when the Animal retires into his Case, they are brought together in a close and curious Order, so as easily to be drawn in. Their general Figure when expanded is that of a Cup, whose Base and Top are of an *Horse-Shoe* Form ; but they present sometimes a very different Appearance, by separating into four Parts, and ranging themselves in such Sort as to represent four separate Plumes of Feathers. --- *see fig. 22.*

I could never discover any Eyes they have, and yet find some Reason to believe they see: for on being set in the Light of the Sun,

Sun, or a Candle, or brought out of the Dark into the Day-light, though contracted before and retired into the Bell, (as indeed they generally are when in the Dark) they constantly extend their Arms for Prey, and shew evident Signs of being pleased.

Besides the particular and separate Motion each of these Creatures is able to exert within its own Case and independent of the rest, the *whole Colony* has together a Power of altering the Position, or even of removing from one Place to another the Bell or common Habitation of them all. Hence this Bell is seen sometimes standing perfectly upright, (as *fig. 15* and *17.*) sometimes bending the upper Part downwards (as *fig. 16.*)

It has been mentioned already, that between ten and fifteen of these Animals dwell together, as it were a little Community, in one Bell-like Case or common Habitation: but their Number increasing, this Bell may be observed to split gradually, beginning from about the Middle of the upper or anterior Extremity, and proceeding downward towards the Bottom, till they separate at last intirely, and form two compleat Colonies, independent of each other; one of which sometimes removes itself to another Part of the Vessel. The Manner how the single Animals propagate I have never been able perfectly to discover, though there is some Reason to conjecture it may be by the

Means of Eggs ; as small opake Bodies of a constant and determinate Figure are sometimes seen lying in their Bells : and unless they are Eggs I know not what to make of them. Their Shape is nearly that of a Weaver's Shuttle, being composed of two circular Arcs, whose concave Parts are towards each other. The Breadth is about two Thirds of the Length, and in the Middle of each a circular Spot appears more opake than the rest, which possibly may be the Embrio. But as I never saw any of them come to Perfection, I can make no farther Judgment of them than what their Situation and Form suggests. They are represented *fig. 15. a.*

The Bells, or Colonies of these Animals, are to be found adhering to the large Leaves of *Duckweed* and other Water Plants ; and may easiest be discovered, by letting a Quantity of Water, with *Duckweed* in it, stand quietly for three or four Hours in Glass Vessels, in some Window, or other Place where a strong Light comes: for then, if any are about the *Duckweed*, they will be found, on careful Inspection, extending themselves out of their Cases, spreading their Plumes, and making an elegant Appearance.

They are extremely tender, and require no little Care to preserve them : their most general Disorder is a Kind of Slime or rather Mouldiness, which will sometimes envelope

velope them in such a Manner as to prove mortal. The best Way of curing this is, by gently pouring a large Quantity of Water (perhaps two or three Quarts) into the Vessel where they are kept, and letting it run off slowly: by which Means the Sliminefs will gradually be loosened and carried away with the Water.

As to Food, if fresh Water be given them daily, they will find sufficient for themselves; and it is dangerous to try any other Way of feeding them, for the smallest Worms, or other visible Insects one can think of giving them, will tear their delicate Frame in Pieces.

Fig. 15. represents one compleat Colony or Bell, standing erect, with all the Animals out of their Cases, and their Arms extended for Prey; exhibiting all together a very pretty Appearance. Here *a* shews the opaque Bodies supposed to be Eggs.

Fig. 16. shews all the Creatures withdrawn into their Cells, and the End of the Bell inclining downwards.

Fig. 17. the Bell erect, with only one of the Animals coming out, in order to shew its connection with the Bell.

Fig. 18. represents a Colony dividing.

Fig. 19. one compleat Animal, greatly magnified, to shew its several Parts more distinctly. *Viz.*

a, the Horfe-Shoe-figured Head.

b, *b*, the Arms seen from one Side.

c, the narrow Neck.

d, the Oesophagus.

e, the Stomach.

f, the Gut or last Intestine, through which the Food passes, after being digested in the Stomach.

g, the Anus, where the Fæces are discharged in little Pellets.

b, i, that Part of the Bell which surrounds the Body of the Animal, and closes upon it when it retires down.

Fig. 20. The Head and Arms seen in Front.

Fig. 21. The Head and Arms closing together, and disposing themselves in order to be drawn down into the Bell.

Fig. 22. The Arms arranged in a Feather-like Appearance.

C H A P. XI.

The SATYR.

IFrequently have taken notice, in several Infusions of Vegetables, of a little crustaceous Animalcule, whose Picture is given *fig. 25th.* of this same *Plate XII.* The Shell of this Creature is so exceedingly transparent, that unless great Attention be given it cannot be discerned at all. It seems to cover the Back only of the Animal: its Belly,

ly, and under Parts, appearing to have no Shell. The Middle of the Body, containing the Bowels, (whose peristaltic Motion may be discerned) is somewhat opaque, and in the Shape of a Bottle with the Mouth downwards; the Sides are transparent, and shew many Vessels running through them. Four Legs, or Fins, divided near half their Length, and serving either to walk or swim, issue from the opaque Part, and reach beyond the Edges of the Shell: and two thicker and shorter Limbs, pointing directly forwards, each of them armed with a sharp Claw, are placed at the Head-End, and probably are the Instruments wherewith it takes its Prey. On each Side of the narrow Part of the opaque Body, at some little Distance therefrom, one sees a round black Spot, the use whereof I dont pretend to guess.—This Animal is brisk and vigorous, swimming sometimes with great Swiftneis through the Water, at other Times it creeps along at the Bottom of the Drop, and now and then skips nimbly like a Flea. It often shews itself in Profil, as represented *fig. 23.*

Monfieur *Joblot* (whose Imagination has frequently exaggerated the Figures of Animalcules to be found in Water,) tells us, that he once discovered, in an Infusion of the *Anemony*, an Animalcule having on its Back a Mask or exact Representation of a *Satyr's Face*; and he gives a Picture suitable to that Idea.

Idea. But, making a considerable allowance for the Fruitfulness of his or his Painter's Fancy, I think it not unlikely, that the Subject we are treating of might have been the little Animal he saw : for the two black Spots, with the Part of the Bowels that comes between them, have some Resemblance of a Nose and Eyes ; the two Points, which terminate the Shell at the Tail-End, appear something like a piqued Beard ; the Distance between may pass for a Mouth, and the Whole put together, might by a true Lover of the *Wonderful*, be worked up to the extravagant Likeness of a *Satyr's Face*.-- But this is mentioned only by the by, and as a Reason why I give it the Name of *Satyr*.

C H A P. XII.

Three AQUATIC ANIMALS described.

TOWARDS the End of *September*, in the Year 1743, some Water taken from a Ditch at *Tooting* in *Surry*, (wherein many *Polypes* of an exceeding small Kind had been discovered, by my worthy, inquisitive, and obliging Friend the Rev. Dr. *Henry Miles*, F. R. S.) was sent to me in a Phial, in order to be examined. And whilst I was viewing the *Polypes* with the Microscope, I had

had the Pleasure of finding three different minute aquatic Animals, which I had never before observed.

The first of these seemed to the naked Eye like a very small and slender Worm, of about one Third of an Inch in Length : but the Microscope soon shewed its real Form and the Singularity of its several Parts, in the Manner they are represented *Plate XII. fig. 24.*

From the Fore-part of the Head of this Animal a long *Proboscis, Horn, or Snout* was extended, moving itself every Way with great Readiness, and issuing from that Part of the Head where the Mouth should be ; which anterior Part changed its Appearance according to the Motions of the Instrument, sometimes extending itself and becoming more slender, and at other times shortening itself and growing thicker. About the Head it had somewhat of a yellowish Colour, but all the rest of it was throughout perfectly colourless and transparent, except the Intestines, which were considerably opaque, and disposed as in the Picture. In them also a peristaltic or internal Motion was distinctly visible. Along its Sides were several *Papillæ* with long Hairs growing from them: its Tail ended very bluntly : it had two black Eyes, and was extremely nimble.

I found only this single Animal of its Kind, from which I drew up the above Remarks

marks at the Time of viewing it, when its Figure was likewise carefully taken ; but soon after I had the Favour of a better Account in a Letter from Dr. *Miles*, who had Plenty of them under his Inspection : and this I shall lay before the Reader in the Doctor's own Words.

“ The Worm found in the Water in which
 “ I met with the *Polypes* in this Neighbour-
 “ hood is of various Sizes, from about $\frac{1}{4}$ of an
 “ Inch to half an Inch, and about the Thick-
 “ nefs of the Worms we feed the *Polypes*
 “ with. It is transparent, excepting in the
 “ Middle where the Gut runs, which the
 “ Fæces make look of a dirty colour, but it
 “ has no Redness as the Worms have, and
 “ for that reason might be reckoned a-
 “ mongst the Insects which some have
 “ erroneously called *exanguious*, since our
 “ Eyes, assisted by Glasses, shew them to
 “ have Blood : as I shall presently tell you
 “ this has.

“ The Form of it (when magnified I
 “ mean) resembles in many Particulars some
 “ of our Catterpillars that feed on Vegeta-
 “ bles. It is infected as they are, and it is
 “ hairy : here and there a little Tuft of
 “ Hairs, and in other Places a single Hair
 “ regularly growing out of the Sides, as I
 “ have attempted to represent in the Fi-
 “ gure. I saw the peristaltic Motion of
 “ the Gut, and once saw it exclude Fæces,

“ three

“ three or four Clusters together, which re-
“ sembled exactly those of our common
“ Catterpillars, or of the Silk-worm Catter-
“ pillar. But the most remarkable thing
“ in this Creature is a Kind of *Horn* or *Feeler*
“ which it seems to carry in its Mouth, and
“ may be just seen by the naked Eye if
“ your Water be clear. 'Tis in the larger
“ ones about $\frac{1}{10}$ Inch long. This (I know
“ not what to call it) it waves to and again
“ as it moves in the Water, or when it
“ creeps up the Side of the Glass ; which
“ it does somewhat like a young Lecch, but
“ without contracting its Body so much, and
“ rather in the Manner that Catterpillars do.
“ I have not been able to learn, though
“ I have viewed it a long Time together,
“ whether it gets any Food with this Hörn,
“ nor can I find whether it be hollow : but
“ I am certain 'tis not pointed, but rather
“ blunt : nor have I ever seen it contracted
“ any thing considerably.—I must not omit
“ to tell you, that 'tis a very tender Crea-
“ ture ; for in taking up the first I viewed
“ with a Quill, as we do the *Polypes*, by the
“ Side of the Glass, I injured it so much,
“ that it was nearly cut in two, and its
“ Horn came off, after it had been a little
“ while in the Drop of Water upon the
“ Slip of Glass. I was glad of this last Ac-
“ cident, as it gave me an Opportunity of
“ observing the Horn or Feeler in a better
“ Manner

“ Manner than I could otherwise have done ;
 “ for hereby it appeared to me to have grown
 “ into the Fore-part of the Head or Mouth,
 “ and to have been placed (as some Bones
 “ are) in a Socket, the End next the Head
 “ seeming claviculated or clubbed, and con-
 “ siderably bigger than the other : the Head
 “ also in the Place where this Horn had
 “ been inserted was left with a Hollow sui-
 “ table to such Articulation. I am doubt-
 “ ful whether the Creature can contract this
 “ Horn or not, nor can I tell whether there
 “ be any Communication between it and
 “ the Entrails. I took Notice that in or-
 “ der to wave it about considerably it con-
 “ tracted its Head a little, as if to hold it
 “ faster and have more command of it : and
 “ indeed the Head resembles a Sort of For-
 “ ceps grasping this Feeler at the thick
 “ End.

“ The said Horn or Feeler has no-
 “ thing remarkable in its Texture, but ap-
 “ pears smooth and transparent, without
 “ any of the Asperities that we find on the
 “ Arms of the *Polype*. I shall only add,
 “ that the Gut runs visible from the Head
 “ to about $\frac{1}{20}$ of an Inch of the Tail, where
 “ it ends insensibly, for without a good
 “ Magnifier you cannot discern its *End*, but
 “ it seems to be resolved into the Body of
 “ the Worm. The Tip of the Tail is very
 “ transparent, and there I saw with great
 “ Delight

“ Delight the Circulation of the Blood in
“ the Middle, running to the Gut, as it
“ seemed, and losing itself thereat, by reason
“ of its Opacity. --- *Quærenda.* What is
“ the Use of this Horn or Feeler? What
“ Food does the Creature eat? One would
“ think nothing taken in by the Horn, *if it*
“ *be hollow*, because the Fæces are so gross:
“ if not, how does it take its Food? And
“ what is it in its mature State?

The second Sort of Animal I discovered in this Water was about a Line in Length, having a large Head, with two black Eyes in Sockets considerably projecting, and pretty long *Antennæ*. Its Head, Body and Tail, were divided like those of the Bee or Wasp Kind: from the End of the Tail issued three long Branches beset with Hairs, and each appeared somewhat like the Stem of a Peacock's Feather: they could separate more or less, be brought together, or move in any Direction that suited the Conveniency of the Creature. It had six Legs, which served either to swim or creep, with Claws at the End of each. The Head, Body and Tail were covered all over with a Sort of Hair or Down, and under the Tail were a Couple of moving Parts like Fins, wherewith it seemed to guide its Course in swimming. It was extremely agile.

Plate XIV. N^o 7. A. represents this Animal as viewed by the Microscope.

Y

The

The Tail Part more enlarged, with its under Side turned upwards to shew the Fins, and its three Branches displayed, is shewn at the Letter B.

The third Sort of Animal, whose Figure may be seen in the same *Plate* at M, had an odd Head, flattish before, without any Appearance of Eyes: a Body somewhat opaque, and a Tail that could divide occasionally. From about the Middle of the Body a very thin Membrane was extended, on each Side, as low as the upper Part of the Cleft in the Tail; this was moveable, very transparent, and served as a Fin in swimming. It was very minute, and swam along with a direct progressive Motion, very smooth and regular, but not fast. Sometimes it would change its Figure, and appear somewhat crooked and triangular, in the Manner shewn at N.

C H A P. XIII.

The GLOBE ANIMAL.

IN the Month of *July* 1745, three Phials full of Water were sent to me from *Yarmouth*, by Mr. *Joseph Greenleaf*, having in them several Kinds of Animalcules unknown to me before. Some of the larger Kinds died in their Passage, occasioned I suppose by the Jolts they received, and a
 Deficiency

Deficiency of Air ; the Phials being corked close, and too full of Water to leave them Air enough for Respiration. One kind, however, suffered very little, but when examined by the Microscope was perfectly alive and vigorous, and so numerous in one of the Phials, that the Water might be perceived to swarm with them, though their Size was much too small for the naked Eye to distinguish otherwise than as moving Points. They all died with me in two or three Days, but in that Time I had Opportunities enough to examine them, very carefully, and take a Drawing of them. My Friend Mr. *Arderon* of *Norwich* sent me also, towards the End of the same Summer, some little Account with a Drawing of the same Animalcule, of which he had accidentally discovered a single one in a Drop of Water.

Fig. 27. represents this very singular minute Water Animal, as it is seen before the Microscope. Its Form seems exactly globular, having no Appearance of either Head, Tail, or Fins. It moves in all Directions, forwards or backwards, up or down, either rolling over and over like a Bowl, spinning horizontally like a Top, or gliding along smoothly without turning itself at all. Sometimes its Motions are slow, at other Times very swift : and when it pleases, it can turn round (as it were upon an Axis) very nimbly, without removing out of its Place. Its

324 *Eggs of the small Fresh-Water Snail,*
whole Body is transparent, except where
the circular black Spots are shewn in the
Picture ; of which Spots some had six or
seven, some one, two, three, four or five, and
others none at all. These probably are its
Eggs or young ones ; but the short Time
they were with me, prevented my coming
to a Certainty as to this Particular. The
Surface of the whole Body appeared in some
as if all over dotted with little Points, and
in others as if granulated like Shagreen : but
their more general Appearance was, as if
beset thinly round with short moveable Hairs
or Bristles ; and 'tis not improbable all their
Motions may be produced by some such In-
struments, performing the Office of Fins.

C H A P. XIV.

*Eggs of the small Fresh-Water Snail, and
Animalcules adbering to them.*

THE Group of Figures, *Plate XIII.*
N^o 1. A. represents the magnified
Appearance of a Congeries of the Spawn or
Eggs laid by a *Water Snail* : which Con-
geries of Eggs, as seen by the naked Eye, is
shewn at the Letter B.

The Parent Snail is exhibited of its natural
Bigness C 1 ; its Back upwards toward the Eye,
and

Animalcules

Fig. 1.

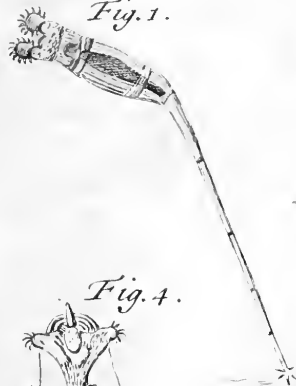


Fig. 2.

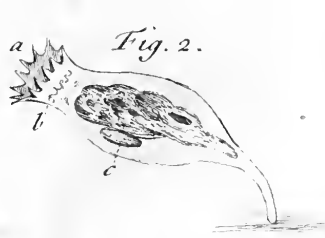


Fig. 3.

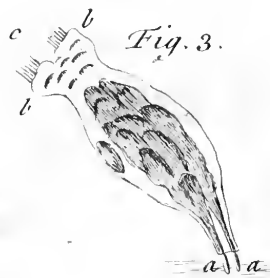


Fig. 6.



Fig. 7.

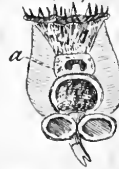


Fig. 8.

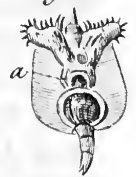


Fig. 4.



Fig. 5.

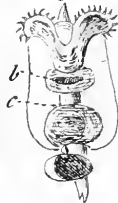


Fig. 9.

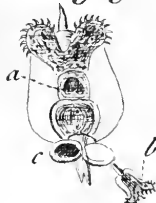


Fig. 10.



Fig. 11.



Fig. 12.



Fig. 13.



Fig. 14.

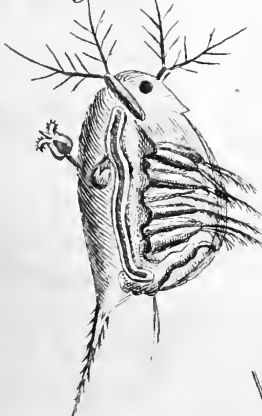


Fig. 15.



Fig. 16.



Fig. 17.



Fig. 18.

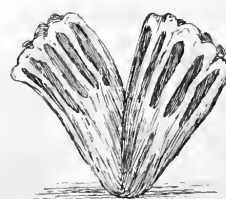


Fig. 21.



Fig. 22.



Fig. 25.



Fig. 26.



Fig. 27.

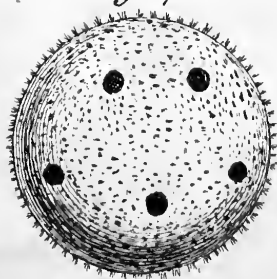


Fig. 19.

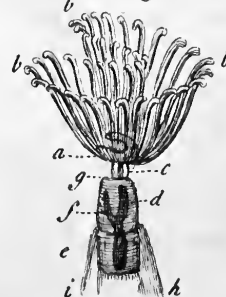


Fig. 20.

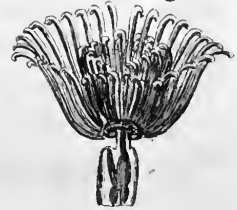


Fig. 23.



Fig. 24.



and its Body extended beyond the Shell, in the Action of creeping from Place to Place.

The same Snail is turned upon its Back C 2 ; that the true Form and Opening of the Shell may the better be understood.

I have frequently kept Numbers of these Snails, for many Months together, in a large Glass Jar, with Polypes and other Water Animals : and 'tis very common for them to fasten their Spawn, in little Masses, against the Sides of the Glass, where the Eggs hatch in about three Weeks or a Month's Time.

The Spawn, when first deposited; appears to the naked Eye like a transparent Jelly ; but if examined by the Microscope, one sees in it Numbers of small and exceedingly pellucid oval Bodies, at little Distances from one another, enveloped in a gelatinous Substance ; having each of them towards one of its Extremities a very minute dark Speck, wherein, if carefully examined by the greatest Magnifier, a *Pulsation* may be discerned.

This Speck will be found to grow larger from Day to Day, and to become a perfect Snail, with its Shell compleat, several Days before it bursts through its Integuments. When the Eggs are about a Week old, the *Embryo Snail* may be discerned in its true Shape, turning itself very frequently within the fine Fluid in which it lies : and the Heart is

326 *Eggs of the small Fresh-Water Snail,*

then a most agreeable and amazing Spectacle, shewing itself very distinctly, and resembling a little oblong Bladder, much less at one End than the other: the *Pulsation* proceeds under the Eye with great Exactness and Regularity, and the Systole and Diastole of this Vessel are nearly equal to those of the human Heart, somewhat more than Sixty *Pulsations* being performed in a Minute, as I have found by several Trials, keeping my Finger at the same Time on my own Pulse, which usually beats two or three Strokes more. The Heart is large in Proportion, and may be always seen, until the Animal increasing in Bulk and becoming consequently more opaque, in some Positions it hardly can be perceived: but as the Animal frequently turns itself within the Egg, a little Patience will bring the Heart in full View again: and that as long as the Embryo continues within the Egg. Nay, even after it is hatched, the Heart may be discovered for some Days through the transparent Shell †.

The general Plan of Nature is so uniform, in the Production of living Animals, though with some little Variations as to the Manner of its Execution, that from what we are able to discover in the very transparent Eggs
of

† The same Progression I have been describing, was observed at *Norwich*, by Mr. *Ardenon*, in the *Cornu Ammonis* River Snail.

of this little Creature, some reasonable Conjecture may be formed of what happens in those of much larger Kinds.

According to the usual Order of Nature, every *Embrio* of an Animal is lodged for a Time within the *Uterus* of the Parent, inclosed in a Case or Egg, whose outer Coat is either hard and shelly, or tough and membranaceous, affording a proper Bed and Covering to preserve it from external Injury.

In Animals that are *oviparous*, this Egg is excluded out of the Body of the Parent, some considerable Time before the *Embrio* has attained a Size and Strength sufficient to endure being exposed to the open Air without Prejudice : during which Time, it takes in Nourishment, and its Limbs acquire a continual Growth, from proper Juices in which it floats, and wherewith the Egg is replete. For the Egg, between the Time of its being laid, and that of its hatching, can receive no other Benefit from the Parent, than what the natural Heat of her Body can afford it : And Experience teaches that the like Degree of Heat, supplied by any other Means, with the same Constancy, will be of equal Service †.

On the contrary, in *viviparous Animals*, the Egg is retained in the *Uterus* of the Parent,

Y 4

rent,

† In the Eggs of numberless Species, which shew no Concern for them after they are once laid, no more Heat at all is necessary, than what is common to the Air or Water in which they are exposed.

rent, till the *Embrio* having attained a certain State of Maturity, endures Confinement no longer, bursts open the Integument, Case, or Shell that inclosed it, and issues therewith from the Body of the Parent: until which Time the *Embrio* receives its Nourishment from the Blood and Juices of the Parent, which are conveyed into the Body of the *Embrio*, by certain Vessels of the Parent that inosculate with correspondent Vessels of the *Embrio*, and at the Birth become separated therefrom.

Hence it appears probable, that the original Principle of Life, the gradual Expansion and unfolding of the Members, and the Progression towards Maturity and Birth, are nearly the same, whether the *Embrio* be hatched *within* the Body or *without* the Body of its Parent; which seems to be the chief Difference between viviparous and oviparous Production. But to proceed.

For some Days after the Water Snail has laid its transparent Egg, the Microscopic Speck of Life, wherein the tender Limbs and Rudiments of the Animal are most wonderfully folded up and contained, has no other Appearance of Life than only a *languid Pulsation*, but just discernable by the best Glasses and the most curious Eye. As this Speck increases in Bigness, it exhibits, gradually, the Figure of a minute Snail, and acquires an Ability of moving itself very slowly.

slowly. After this, its Size and Motion becomes every Day more conspicuous, its spiral Revolutions shew themselves more distinctly, its Form becomes more perfect, a Shell, unconceivably delicate, is produced over its tender Body : it now occupies a considerable Part of the Egg, turns itself vigorously, and even creeps within it, and in due Time breaks it, and issues forth.

'Tis not unlikely this is Nature's constant and regular Course in the Production of all Creatures that are *oviparous* ; and that she proceeds nearly in the same Manner to promote the Growth and Birth of the *Embryo* in the Human Race, as well as in all other Creatures that we term *viviparous*, seems to me no less probable.

After this Digression, which I was insensibly led into, I return to take notice, that the Eggs which the Drawing exhibits were about a Fortnight old ; at which Time the young Snails were of such Size, in Proportion to the whole Room contained within the Eggs, as those marked *c, c, c*, may pretty nearly shew.

The other aquatic Animalcules represented as hanging about this Parcel of Eggs, are no other than what were really found adhering to it when it was viewed by the Microscope : and they were exactly situated as in the Picture, which was taken without the least Exaggeration. Their extreme Minuteness

ness rendered them absolutely invisible to the Eye, for which reason no attempt is made to shew them at the Figure B.

A little Colony of Bell-Animals appear at *d*: their long Tails are fastened to the gelatinous Substance wherein the Eggs are laid; they stretch themselves out, and play vigorously in the Water; numberless Fibrillæ round the Mouth of each Bell agitating the Water to a considerable Distance.

More of the same Bell-Animals are seen at *e*, curling their Tails, in the Manner of a Screw, and pulling themselves back with a sudden Jerk, as they constantly do when discomposed by any thing. But when all is quiet, they slowly extend again in the Water, as far as their Tails permit.— These Bell-Animals are found very frequently adhering to little Bits of Stick, Leaves, Stones, or other Matters that have lain some Time in stagnant Water, either in the Ditches abroad, or in Glasses kept in the House with Infusions or Water-Animals: and their Motions are very entertaining*. Many of them are sometimes seen adhering by their Tails to one another.

On both Sides this Parcel of Snail's Eggs, are shewn, in different Attitudes, several little Creatures, of a Kind which I have been used to call the *Funnel-Animal*. They fasten by their Tails to whatever comes in their
Way,

* Vid. Microscope made easy, p. 91.

Way, and then opening their anterior End, exhibit a wide Mouth somewhat of a Funnel Form, though not compleatly round, but having a sort of Slit or Gap that interrupts the Circle. The Lips or Edges of this Opening are furnished with Multitudes of little Fibrillæ, which by their brisk and continual Motions excite a Current of Water, bringing with it abundance of minute Particles of Matter and living Animalcules which they swallow greedily.- One of them in the Posture above described may be seen at the Letter *f*.----- They can fashion this Mouth or Opening into the several Appearances shewn in the Picture.

If any thing touches or approaches very near them, they shrink back and contract, as at the Letter *g*.

These *Funnel-Animals* never keep together in Clusters, but live separately and independent of one another, swimming freely through the Water, seemingly in Search of Prey, and after a while fix themselves to any thing they meet with.

Mr. *De Reaumur* and Mr. *Trembley* distinguish the little Creatures I have been describing by the Name of * *Tunnel-like Polypi*: and the last mentioned Gentleman, to whose inde-

* I have not the least Objection to this Name, though I here retain what I had given them myself long before either of these Gentlemen had published theirs: and I am pleased to find our Ideas of this Creature so near alike,

indefatigable Industry we are so greatly obliged for many curious Discoveries of several Kinds of what he calls *Polypi*, has, by the Help of an ingenious † Contrivance to fix the Magnifiers of his Microscope close to the Glass Vessels where he keeps these Creatures, found Means to observe the very extraordinary Manner of their Increase; which I shall take the Liberty to present the Reader, from the Account given by himself to the *Royal Society*, and printed in the *Philosophical Transactions*, N^o 474.

“ These *Tunnel-like Polypi* do also multiply by dividing themselves into two, but they divide themselves otherwise than the *Clustering Polypi*: they neither divide longitudinally, nor transversely, but sloping and diagonal-wise. Of two *Tunnel-like Polypi*, just produced by the division of one, the first has the old Head, and a new posterior End; and the other the old posterior End, with a new Head. I shall call that which has the old Head, the *Superior Polypus*; and that which has the new Head, the *Inferior* one.

“ The first Particulars observable in a *Tunnel-like Polypus* that is going to divide, are the Lips of the *Inferior Polypus*; I mean those transparent Edges that are so conspicuous

† A Description of the Apparatus here referred to, is given by Mr. *Trembley*, N^o 484. of the *Phil. Transf.* and a Figure explanatory of the same may be seen Tab. I. *fig.* 4. belonging to that *Transaction*.

“ spicuous in the *Polypi* when entirely formed. These new Lips first discover themselves upon the *Polypus* that is going to divide, from a little below the old Lips, to about two thirds of the length of the *Polypus*, reckoning from the Head: but these new Lips are not disposed in a strait Line, according to the Length of the *Polypus*, but run sloping near half way round about. These Lips are known by the motion in them, but which motion is at first very slow. That Portion of the Body of the *Polypus*, that is bounded by these new Lips, then gathers up itself: the new Lips insensibly draw together and close; whereby there forms itself, at the Side of the *Polypus*, a Swelling, that is soon found to be the Head of the new one, bounded by the new Lips first discovered. Before this Swelling is grown very remarkable, one begins to distinguish the two *Polypi* which are forming themselves; and when that Swelling is considerably increased, the two *Polypi* will be discovered, no longer joined but by a small Portion to each other. The *Superior Polypus* no longer adheres to the *Inferior one*, but by its posterior Extremity, which is still fixed on one Side of the *Inferior Polypus*: the *Superior Polypus* then begins to make Motions that seemingly tend to the separating of him from
“ the

“ the other ; and in a little time he becomes
 “ quite detached, swims away, and fixes
 “ himself elsewhere.-- I have seen one come
 “ and fix at the Side of the *Inferior Polypus*,
 “ from which he was just before separated.
 “ The *Inferior Polypus* remains fixed in the
 “ same place, where the *Polypus* was, that
 “ is now divided, and of which he was only
 “ the half, before the Division took place.”

The little oval Bodies at *b*, were enveloped in the slimy Matter of the Snail's Eggs : they appeared somewhat opaque, but without Motion, and were probably the *Aureliæ* of some Water Insects.

C H A P. XV.

Of CLUSTERING POLYPES.

BEFORE the Reader enters on this Chapter, let me advise him to cast his Eye with a little Attention on *Plate XIII.* N^o. 4, 6, 10 and 13, which will prepare him to understand more perfectly the Account of what are here termed the *Clustering Polypes*, a Name I call these little Creatures by, in Conformity to Mr. *De Reaumur* and Mr. *Trembley*, who have given that Appellation to all the different Kinds of Animalcules that are found hanging together in the Water, after the like Manner.

During

During all the Spring and Summer Seasons, but especially in the Months of *April* and *May*, great Abundance of these, of different Species, are to be found on the Shells or Eggs of Water Snails, on the Leaves of *Duckweed* and other Water-Plants, on little floating Sticks, Straws, or whatever else lye upon or near the Surface of stagnant Ditches or Ponds, for they don't chuse to be at any great Depth in Water. The Reason they have been but lately and so little taken notice of, is, I apprehend, their extreme Minuteness, which renders them invisible, unless by a very good Light, and with Glasses that magnify considerably: at the same Time an Area, sufficient to take in their whole Groups or Branches, must come in View, or else no Idea can be formed of them; and we know, 'tis not many Years, that *Microscopes* have been so far improved, as to command a large and well illuminated Area by Glasses that magnify much, or to have proper Conveniencies for examining Objects even in a single Drop of Water.

Through all the different Species of this Kind of Animal, there is an Analogy or Uniformity, as to the general Figure of their Clusters or Colonies. Each Colony seems constantly to arise from one Stem or Stalk, which is always affixt to some extraneous Body: This Stem divides into a Couple of smaller ones, each of which subdivides in-

to another Pair, and those branch themselves out again, in the same Manner, till the Cluster is completed. The Extremities or Heads of the small Stalks are the Bodies of the Animals, in the Differences of whose Figure consists the Varieties of the Species. Being situated in this Order round the common Stem at different Heights and Distances, they make a very pretty Appearance, when extended in the Water; not ill resembling a Nofegay of Cowslips, or some such Kind of Flowers. And one would imagine the several Heads and their Pedicles to proceed from one common Stem, as the Branches and Flowers of a Plant do from one common Trunk; but a contrary Progression takes place here: for in a Plant the Trunk produces Branches, and those Branches again produce Flowers; whereas the Head here is prior to the Pedicle, and the Pedicle to the main Stem, as will by and by be shewn.

The Heads, or little Animals, (of which Multitudes sometimes are dependent from one Stem,) open their anterior Ends, and play about very briskly in the Water, as far as their respective Pedicles will permit; but every now and then, one or other of them springs back with a sudden Contraction, which may probably be when it has caught something that it retires to eat: for this they do when nothing at all offends them; but if they are made uneasy, by shaking the
Water,

Water, or touching them with any foreign Body, both Stem and Branches instantly contract together, and extend not again till every thing is perfectly at rest.

But though they are found thus conjoined in Colonies, each Head is a perfect Animal, and can detach itself from the rest, live separately, and become the Parent of a new Colony, as most of them do after a certain Time. All of the same Community act after one common Law, in contracting or extending the main Stem as well as their respective Pedicles at the same Time, though each can contract or stretch itself out at Pleasure, without the Concurrence of the rest, as far as the Extent of its own Pedicle. When a whole Colony contracts together, the main Stem seems to pull back the several Pedicles, and those Pedicles the little Animals at their Extremities : but here the Truth is contrary to the Appearance, for the Animals themselves begin the Motion that pulls them back, by a sudden Endeavour to draw up their Pedicles to their Bodies, which Motion the Pedicles communicate to the main Stem, and thereby contract that also : Somewhat in the Manner of a Hair, which jerked suddenly (not to break) and then let go again, flies back with an elastic Force. And that the Case is thus seems pretty certain, because after one of these Animals breaks off from its Pedicle, and leaves the

Z

Colony,

Colony, the deserted Pedicle becomes immediately destitute of Motion ; and when all of them are gone, (as often happens) the Stem and Pedicles, though still adhering as they did before, are unable to move at all.

The main Stem grows large in proportion to the Number of its Branches, which sometimes are very numerous ; so that it is probably a Continuation of all the Tails or Pedicles of the little Animals conjoined together. The Stem and Pedicles look usually very transparent, and like hollow Tubes.

The several Species of these Polypes are nearly alike as to the above Particulars, and differ chiefly in the Length and Size of their little Bodies, and the *Apparatus* wherewith their Mouths are furnished. — Amongst all I have any Knowledge of, no Sort is more common than that represented at N° vi. When the little Animals of this Species stretch themselves out and open their anterior Ends, each of them appears of a Bell-fashioned Figure, with a Kind of Lip turning itself outwards round the Rim of the Bell, which Lip is furnished with Numbers of *Fibrillæ* that vibrate nimbly in the Water, and cause a *Vortex* reaching to a surprizing Distance, in proportion to the Smallness of the Animal : which *Vortex* is shewn *a a*. — When great Plenty of these are lodged together on a Snail, Leaf, or other Body, they seem of a whitish Colour

to the naked Eye, but before the *Microscope* they appear very transparent, tho' with somewhat of a brownish Cast. Their Tails when contracted are drawn back and disposed in spiral Lines, like those of the *Bell-Animal* described pag. 330.

The Species whose Figure is given N^o iv. is much more uncommon. --- Its main Stem and Branches resemble the foregoing, and so does the general Figure of its Body, but its Mouth is remarkably different, for instead of the very small *Fibrillæ* of the last mentioned Species, the Head of this is furnished with two large Arms, by the vigorous Motions of which backwards and forwards, a Stream of Water is made to pass by its Mouth, whereby the Creature is enabled to supply itself with Food, which is taken in between these two Arms. And indeed it is amusing enough to observe the Behaviour and Artifice of this little Creature upon the Occasion ; for as soon as the Prey is swallowed down it instantly retires to the main Stem, by contracting its Pedicle : and by flattening its Body, and bringing the Sides nearly together, it prevents any Possibility of the Prey's escape. After it has continued thus contracted for some time, it extends itself very leisurely, not unlike the *Bell-Animal* : but in our present Subject the Pedicle or Tail when contracted seems as if it was shrivell'd up, whereas in that it falls back in

spiral Lines. The Figures of these Animalcules when playing in the Water are shewn 2 2 : and it is very common, in this and every other Kind of the *Clustering Polypes*, for the little Animals either to detach themselves *, or be broken off by some Violence from their Pedicles ; the Appearance of such deserted Pedicles, which have no longer any Motion or Use, is represented 3 3 ; and their Appearance is much the same in every other Species.

A single Animalcule with its two remarkable Arms is shewn, greatly enlarged, at N^o v. The Diameter of its Superficies next the Eye being magnified about 400 times, and consequently the whole superficial Area of one of its Sides (which is all the Eye can command at once) 160000 times ; according to which Calculation its Bulk would be magnified 64000000 times.

Those Animalcules of the same Species, hanging by their Pedicles, N^o VII. are magnified in their Diameter about 40 times, 1600 times in their Superficies next the Eye, and in their Bulk 64000 times. --- All the other Species of *Clustering Polypes* expressed in this Plate are magnified nearly in the same Proportion,

* When an Animalcule is separated from its Cluster, it swims about in the Water, until it fastens its little Pedicle to somewhat ; and it can detach itself again and seek some other Situation so long as it continues single ; but after it begins to multiply, the Pedicle never loosens itself again, none but single Animalcules being ever seen swimming.

Proportion, whereby the Reader may form some Conception of their Minuteness: and yet, small as they are, they are Whales in proportion to the Animalcules they swallow down.

N^o x. represents a Colony of another Species of *Clustering Polypes*, two single ones of which magnified in the above Manner are shewn N^o xi. and N^o xii.

These when extended in the Water exhibit a Couple of projecting Parts at their anterior End, furnished with Numbers of vibrating *Fibrillæ*, that produce a Current of Water by their quick Motions, and thereby procure them Food. See N^o xii. -- There are some with three of the like Projections, &c. See N^o xi.

N^o xiii. Shews a very extraordinary Species of this Kind of Animalcule, the Body whereof is much longer, its Pedicle shorter, and the Connection of the Individuals to each other in the same Colony is very different from all the rest: for here no main Stem is seen, but all the Pedicles are joynd in one Center, round which the little Animals extend themselves circularly, at nearly equal Distances, and make a very pretty Appearance. But nothing relating to them is more worthy Notice, than the curious and wonderful *Apparatus* whereby they take their Prey, which the two greatly magnified *Figures* at N^o xiv. will assist the Reader to understand the following brief Description of.

The Body of this Animal is very transparent, seems to be hollow and somewhat shelly, and is in Diameter at the broadest Part, (which is about the Middle Way between its Mouth and Tail) nearly one fifth of its Length: it lessens from thence towards both Extremities, tapering pretty suddenly towards the Tail End, and terminating in a long slender Tube near a Quarter of the Animal's Length. Towards the Mouth End it diminishes more gradually, and not so much, being no where less than one Half of its greatest Diameter: it widens again a little about the Mouth, which is quite open like that of a Jug or Pitcher, and seems not capable of Contracti-
 on, or Dilatation, or furnished with any *Wheels* or *Fibrillæ*, as the Mouths of the other Species of these Animalcules are: but to make amends for such Deficiency, it is provided with a moveable *Operculum* or *Cover*, connected to its Body, by a long Ligament or Muscle, which extending downwards (through the Body or Shell) is affixed within-
 side of it near the Tail. See *a a.* --- This Ligament is sufficiently long to permit the *Operculum* to be lifted up to some Distance from the Mouth, in which Situation six *Fibrillæ* appear placed round the Border of the *Operculum*, at Distances nearly equal, (*vid. b.*) These *Fibrillæ* have a vibrating Motion like those at the Mouths of the other *Clustering Polypes*, and serve by the Current they ex-
 cite

cite in the Water to hurry the Prey into the Mouth of the Animal which stands open to receive it ; then by shutting the *Operculum* down immediately all escape is prevented. After a little while the *Operculum* is lifted up again leisurely, and in Readiness for another Capture.

When the *Operculum* is drawn down the *Fibrille* are no longer discoverable, and the Ligament whereby the opening and shutting is performed appears in a flaccid relaxed State, as at *a*.

One of the two magnified Figures in the Plate represents the Animal with its Mouth open and the *Cover* up, as it appears when hungry ; the other shews the *Cover* drawn down after it has seized its Prey †.

Having described these several Sorts of *Clustering Polypes*, (and I make no Doubt there are many other Species and Varieties of them unknown to us at present) I proceed to consider their prodigious and speedy Propagation and Increase, the Manner whereof is no less surprizing than all the other Particulars relating to them : and as to this Affair (though I have observed them many times myself with much Attention) I shall chuse to lay before the Reader what Disco-

Z 4

veries

† I never have been so lucky myself as to meet with this Species of Water Animals, but am obliged to Mr. *Arcton*, (on whose Judgment and Fidelity I can depend intirely) for the Figures and Account thereof.

veries the uncommon Diligence and Sagacity of Mr. *Trembley*, who has applied himself more than any body to this Enquiry, has been able to produce : for in such extraordinary Cases 'tis necessary to make use of all the Evidence one can.

“ A single *Polypus* (says he) detached
 “ from the Cluster, swims about the Water,
 “ till it meets with some proper Body to
 “ fix itself upon. It then has a Pedicle, but
 “ which is not longer than the *Polypus* it-
 “ self. In the Space of 24 Hours this Stem
 “ becomes eight or nine times as long as
 “ it was at first ; and it is this Pedicle which
 “ is to become the main Stem of the new
 “ Cluster.

“ After this the *Polypus* multiplies, that
 “ is to say, it divides and splits itself in-
 “ to two lengthwise. --- One first observes
 “ the Lips to be drawn into the Body, whose
 “ anterior Part closes and becomes round :
 “ the anterior Part of the *Polypus* flats itself
 “ afterwards by Degrees, and spreads in pro-
 “ portion, becoming broader as it shortens ;
 “ it then gradually splits down through the
 “ Middle, that is, from the Middle of the
 “ Head to the Place where the posterior
 “ End joins to the Pedicle: so that in a little
 “ while, there appear two separate round
 “ Bodies joyned to the Extremity of the Pe-
 “ dicle that just before supported but one.
 “ The anterior Part of each of these Bo-
 “ dies

“ dies then opens by Degrees, and as they
“ open, the Lips of the new *Polypi* shew
“ themselves more and more ; and, soon
“ after the Separation is compleated, each
“ begins to shew a Pedicle of its own.-----
“ Ten or twelve Hours after, these two
“ *Polypi* again divide themselves each into
“ two more : they soon after put out
“ Branches, and thus retire to a greater Dis-
“ tance from each other.---When two *Polypi*
“ are thus formed by the Division of
“ one, the one is ordinarily much larger
“ than the other : this larger one remains
“ at the Extremity of the Branch where it
“ was, but which Branch lengthens itself
“ more, whilst the other puts out a new
“ Branch which seems to proceed from the
“ first. The larger of these *Polypi* again
“ divides itself generally before the other :
“ and all I have been describing is reiterated
“ several times. Thus a principal Branch
“ is formed, provided with several lateral
“ ones : these lateral Branches become
“ principal, with regard to those which in
“ their turn seem to spring from them, when
“ the *Polypi* at their Extremities come to
“ divide.--- All the *Polypi* of a Cluster do
“ not detach themselves from it at the same
“ Time : those which are nearest to the
“ Origin of the Branches usually detach
“ themselves first. And every *Polypus* so
“ detached, goes and fixes itself elsewhere ;
“ every

“ every one thus becoming at last, if not
 “ prevented, the Principal of a new Cluster.
 Mr. *Trembley* tells us farther, “ that he
 “ followed the Progress of a Cluster in the
 “ Month of *September* 1744. --- It consisted,
 “ on the 9th Day of that Month, but of one
 “ single *Polypus* : this *Polypus* divided itself
 “ that Evening, and at Half an Hour after
 “ Eight of the Clock, there were to be disco-
 “ vered two perfect *Polypi*, whose Pedicles
 “ or Branches continued lengthening till
 “ the Morning of the next Day, being the
 “ Tenth of the same Month of *September*.
 “ At about a Quarter after Nine that Morn-
 “ ing, these two *Polypi* began also each to
 “ divide, so that after a Quarter past Eleven
 “ there were four compleat *Polypi*, whose
 “ several Pedicles formed themselves soon
 “ after. On the Eleventh of the same *Sep-*
 “ *tember*, about Half an Hour after Seven in
 “ the Morning, he found that these four last
 “ *Polypi* had already again divided them-
 “ selves, that is to say, that there were Eight
 “ distinct *Polypi*. --- And he has taken No-
 “ tice of Clusters, the Numbers of whose
 “ *Polypi* have constantly gone on doubling,
 “ from 2 to 4, from 4 to 8, from 8 to 16,
 “ from 16 to 32 : after which he has been
 “ no longer able to count exactly the Num-
 “ ber of the *Polypi*. --- But their Multiplica-
 “ tion is so prodigious, that he says, “ on
 “ *November* 1st. 1744, there was in one of
 “ his Glasses, a Cluster composed of several
 lesser

“ leffer united Clusters, which was above
 “ an Inch over every Way.

These Quotations are taken partly from N^o 474 of the *Phil. Transf.* and partly from the *Appendix* to the 44th *Vol.* of the said *Transactions*. The *Polypes* here particularly intended, are those I have called *Bell-Animals* in the former Part of this Work, and that *Species* whose Figure is given in this *Plate* N^o vi. and its Description *pag.* 338. There is however Reason to believe, that all the other *Clustering Polypes* already taken notice of in this *Plate*, may be propagated after the same Manner.

N^o vii. viii. ix. shew different Appearances of the same Animalcule, which is another Species of the *Funnel-Animal*, *vid.* N^o 1, *f. g.* They are found together sometimes in vast Abundance on the Shells of Water Snails, &c. seeming to the naked Eye like a green slimy Matter. When first applyed to the Microscope they are usually seen contracted, as N^o viii. but being left at quiet for a little while, they change their Figure to that of N^o vii. and swim about very briskly with their large Ends forward. At other Times they appear like N^o ix. having then a toothed Wheel at the Head or largest End, that moves round with prodigious Velocity, in the Manner of the Wheels of the *Wheel-Animal*, already described *pag.* 269, but having a much larger Wheel than either of those the Wheel Animal is furnished with.

Its

Its Gyration is so swift, that without great Attention they can not be seen. The Teeth are most conspicuous when it begins or ends its whirling, or when it becomes sick by Confinement in a Drop of Water. On being disturbed by any thing, they contract themselves as at N^o VIII.

C H A P. XVI.

The MULBERRY INSECT.

THE Figures and Description of N^o XV, 1, 2, 3, were sent me by Mr. *Arderon*, in *March* 1745-6. — He says, that on the first Day of the said Month he found in the Water of a Ditch, at *Norwich*, some exceeding strange Animalcules, which from their bearing some Resemblance to the Fashion of that Fruit, he calls *Mulberry Insects*: though the little Protuberances that stand out round them, equally on every Side, make them rather more globular. Their Bowl-like Motions are much the same as those of the *Globe Animal*, described *pag.* 322; but they did not move so readily from Place to Place, and their Protuberances appeared so loosely connected together, he should rather take them for a Congeries of Animalcules than one single Animal. — As to this Particular he seems however in some Kind of Doubt: and in a Letter received from him afterwards,

wards, he imagines the *Mulberry Insect* may possibly be the last mentioned *Clustering Polypes* with *Opercula*, (N° XIII.) not yet come to their perfect State. He met with several of these Insects, or Congeries of Insects, of different Sizes, and with different Numbers of Knobs or Protuberances, some having 50 or 60, others more or less even down to 4 or 5, but the Manner of moving was the same in all.

CH A P. XVII.

The PIPE ANIMAL.

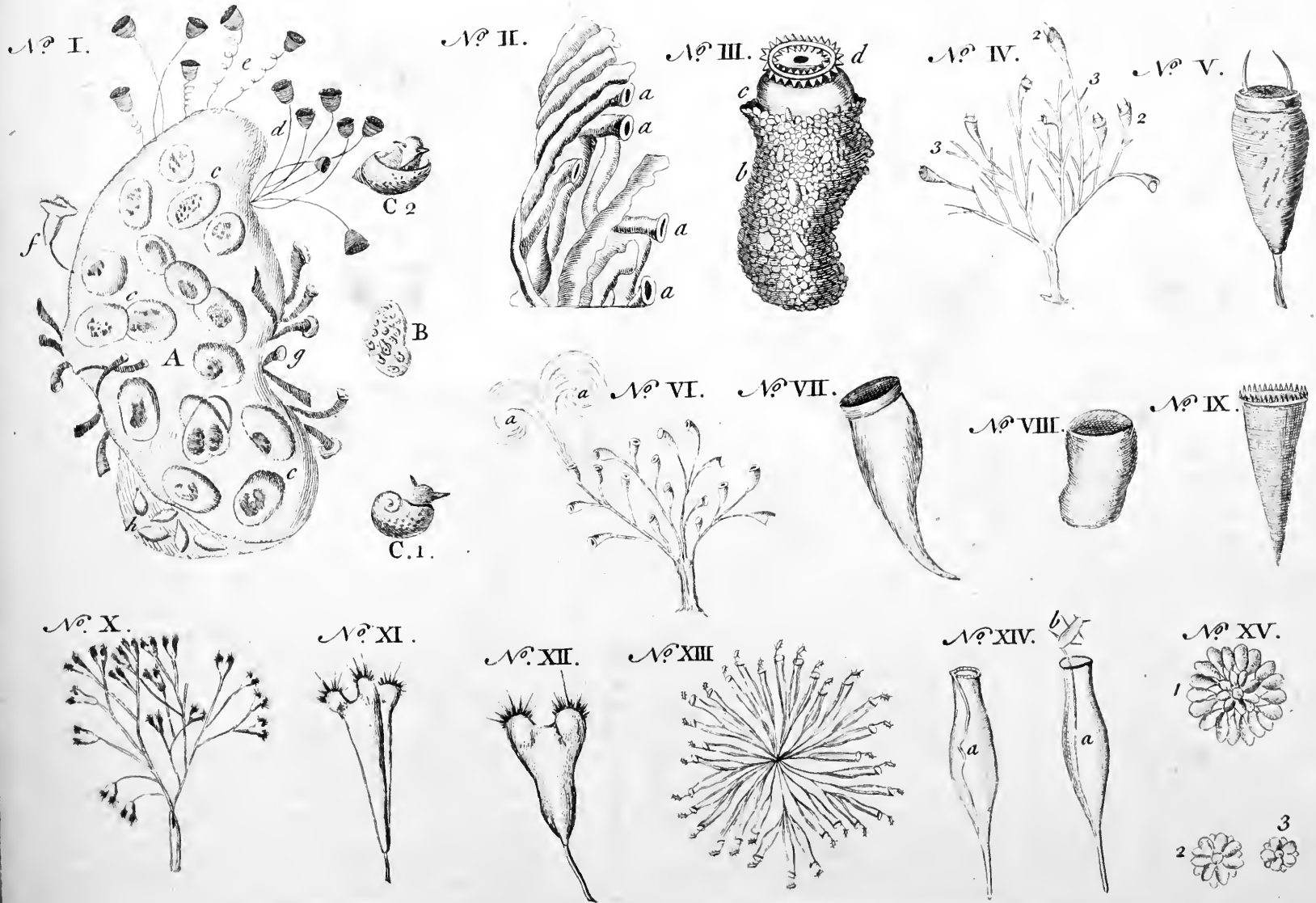
UPON the Sea-shore, on the Coast of *Norfolk*, and without Doubt in other Places, Heaps of Sandy Matter are to be seen at low Water, two or three Feet sometimes in length, composing Multitudes of small Tubes or Pipes, which are the Cases or Habitations of living Creatures. My *Norwich* Correspondent, to whom I stand obliged for this Information, wrote me Word, that a Friend of his broke off and brought to him a small Piece of such a Congeries of Tubes or Pipes, in Shape and Size as at N° II. in which *a a a a* shew the Mouths or Openings of the Pipes wherein the little Creatures make their abode.

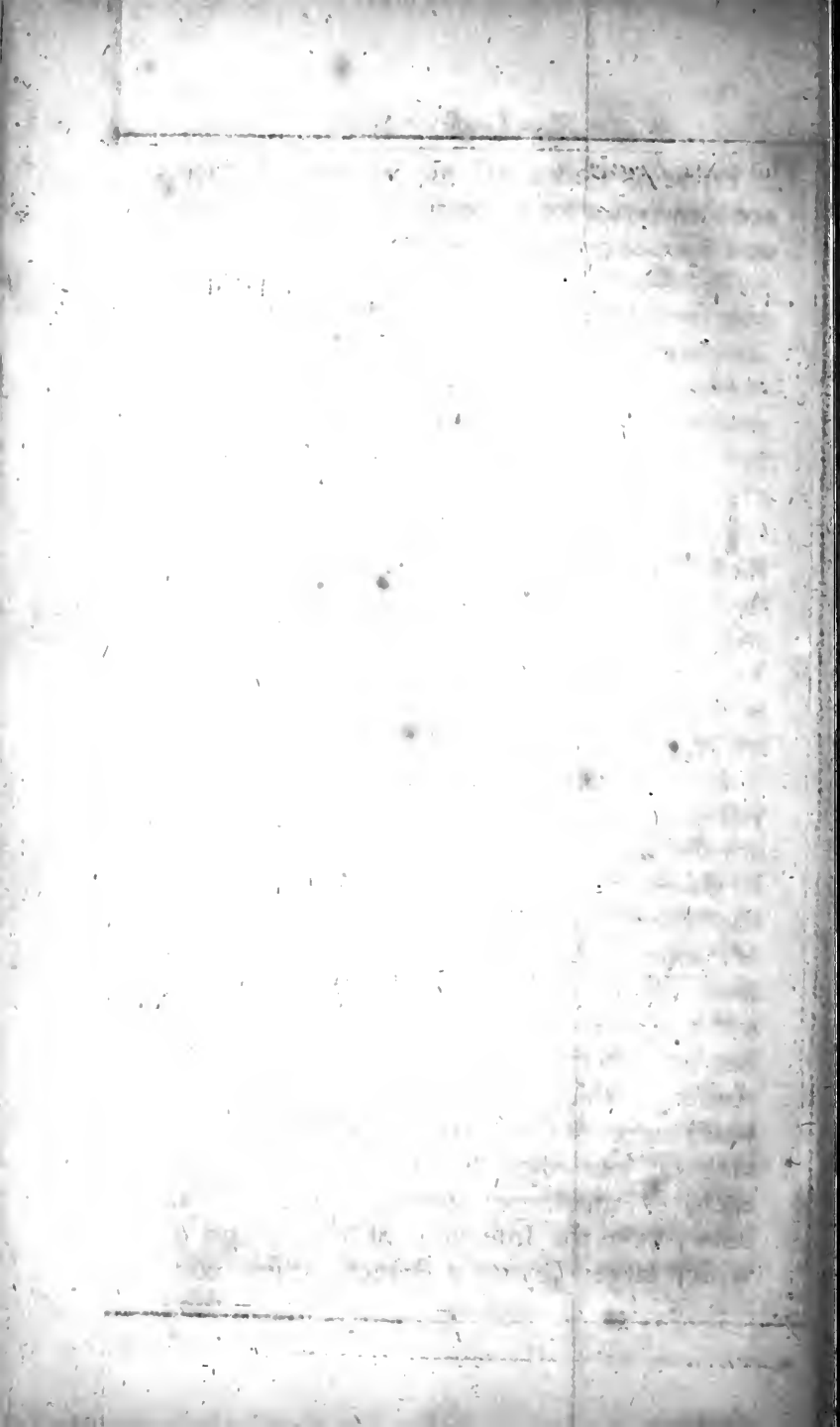
He

He carefully separated one single Pipe from the rest, and placed it in a Glass of Water, to give the little Inhabitant an Opportunity of coming to the Mouth of its Cell, which it did accordingly very soon, and then appeared as at N^o III. where the Figures both of the Animal and its Case are magnified nine or ten times in Diameter.-- The Pipe or Case *b* is made of Sand, intermixed here and there with minute Shells and Sand, all cemented together by a glutinous Slime issuing I suppose from the Animal's own Body *c*, which is composed of muscular Ringlets, (like those of a Worm,) capable of great Extension or Contraction. The anterior End or Head *d* is exceedingly beautiful, having round it a double Row of little Arms, disposed in very regular Order, and able I suppose to extend themselves for the catching of its Prey, and conveying it to the Mouth that appears in the Middle of this anterior End. But the Animal being sick for Want of Salt Water did not extend its Arms at all, and expiring soon after, no Way was left of coming at its true Figure when stretched out.

I am sensible that the Account here given is very imperfect ; but it may I hope induce some curious Body, who lives near the Sea-Shore, and has an Opportunity of so doing, to furnish us with a better.

Animalcules.





Pipes or Tubes of this Size and Figure are sometimes found petrified, and constitute one Species of the *Syringoides*.

C H A P. XVIII.

The Water Hog-LOUSE or Sow.

THE Animal figured *Plate XIV. N° 1.* although an Aquatic, bears so near a Resemblance in its general Appearance to the Millepedes, Sow or Hog-Louse, especially when creeping at the Bottom of any Vessel wherein it is kept, that it may properly enough be called a Water Sow, or Water Hog-Louse.

Its whole Length is made up of nine Divisions, the anterior and posterior whereof are the Head and Tail. To the Head which is almost round, and about the $\frac{1}{2}$ Part of the Animal's Length, are affix'd two very long *Antennæ*, each consisting, next the Head, of four distinct Joynts, and then shooting out a Part extremely slender and tapering, and but little shorter than the whole Body of the Animal; which on a close Examination appears compos'd of many Articulations, having an exceeding fine Bristle issuing from each, as the larger Joynts near the Head have; from the Insertion of the second of which larger Joynts a Branch arises, consisting

sisting of one Joynt, and a slender tapering Part articulated and bristled as the above described, but of no great Length. This is shewn in the Figures, I, II, III. In the Middle of the anterior Part of the Head are placed two very small and short Feelers. Its Eyes, if it has any (which I think its Actions leave no room to doubt) are not discoverable ; either from their Smallness or the Opakeness of the Animal.

The Body (not reckoning the Head and Tail) is composed of seven Divisions, which increase in their Breadth, but not much in their Length as they approach towards the Tail, the Body being about three times as broad at the last of these Divisions as it is at the first. From the first Division next the Head arise two short Claws, terminated by a Hook that can bend down like a Clasp-Knife, and from every one of the other Divisions proceed two long Legs, each composed of five Articulations, and also a single Claw at its End. In these Legs two Blood-Vessels may be discovered, even by a Glass that does not magnify very greatly : one carrying the Blood *from* and the other returning it *to* the Body. The Globules of this Blood, or animal Fluid, appear about ten times as large as those of the human Blood, and their progressive Motion is very slow and languid, whereby they become more distinguishable than the Globules are in the Blood of Animals whose

whose Circulation is swifter. The Legs are very hairy, especially at the Joynts, and so is the whole Body of the Animal, which occasions it to be frequently so covered and entangled with the Dirt and Scurf of the Water, as to prevent its Figure from being truly seen.

The Divisions of the Body are each of them covered on their upper or back Part with a Scale or Crust, extending beyond and hiding the Insertions of the Legs, which however are shewn in N^o 11, where the Animal is turned on its Back. To the hindermost of these Divisions the Tail is fixed, which is perhaps the most remarkable Part of the Animal. Its Length is about three times as much as that of the largest Division of the Body ; its Breadth nearly equal to its Length, but tapering suddenly towards the End, like the Tails of some of the Beetle Kinds. From the back Part thereof, which is covered with a Shell or Crust, arise two joynd Branches, standing out at an Angle of about 45 Degrees to the Plane they rise from, each dividing again into two, and having Bristles like the Legs. The Use of these Branches is not yet discovered.

On the under or Belly Part are placed two Sets of Valves, rising up and falling down, alternately, in a perpendicular Direction: these may probably serve for the Purpose of Lungs, or as the moveable Coverings of the Gills of

Fishes, to breathe through, or regulate some of the other animal Functions. And what seems to confirm this Opinion is, that on depriving the Animal of them, the Circulation in the Legs ceased instantly, though the Creature lived for some time afterwards. The Motion of the Valves, however uniform at any one time, is not always of the same Quickness, being now and then so slow as nearly to beat Seconds, (when it is visible, even by the naked Eye, in certain Positions of the Animal,) whereas they move at other times with above thrice that Velocity. And this seems to be nearly in Proportion to the Temperature of the Weather, their Motions being always slowest in the coldest Seasons. At *b* N° III, which is a Profile View of this Creature, the Valves are shewn as they appear when moving. Their working up and down continually, renders it difficult to be sure of the true Figure, or indeed the true Number of them; but there seems to be four Pair, which move not all together but alternately. The external Pair seems strengthened and supported by a Couple of strong joynted Tendons, as is shewn at N° II. *b*.

The natural Size of this Animal when at its full Growth is about three Tenths of an Inch in Length. Its Motion, notwithstanding the great Number of its Legs, is very slow, awkward and unweildy: and indeed the Length and Slenderness of the Legs seem to
render

render them incapable of supporting the Body in the same Manner as those of other Animals do : so that it more properly may be said to be dragged along by than to be carried on them. This Kind of Motion makes him a very disagreeable Companion to other aquatic Animals that happen to inhabit the same Vessel with him, which he rather chuses to trample on and overturn than to move out of his Way for them. He is however as much tormented in his Turn by Funnel Animals, Bell Animals, Wheel Animals, &c. which frequently fasten themselves upon him, in such a Manner as not to be disengaged by his utmost Efforts.

He swims sometimes, or rather climbs to the Top of the Water, by the Help of his Feet, but cannot remain there for any Length of Time, his Weight immediately sinking him down again : and indeed he generally chuses to continue at the Bottom, where he frequently is found covered and overwhelmed by the slimy Sediment of the Water. He sometimes also brings his Head and Tail together, and forms himself into a Ball in the Manner of the Land Hog-Louse.

As to the Way of their Generation, nothing farther is yet discovered than that they are viviparous : for they are sometimes found having a large Bag hanging down from their Bellies, as shewn at *a*, N^o III. On cutting this open the young ones have been seen

to come out alive, to the Number of seventy or eighty : yet on examining the Animal the Day following the Operation, there still appeared some remaining in the Bag ; but whether they came not all out at first, or that some of them returned in again, was uncertain, tho' the latter seem'd most probable. An old one is sometimes seen holding one of its Young, (when grown even to a considerable Size,) under its Belly between its Legs, which it will not part with unless compelled to do so by some considerable Force.

C H A P. XIX.

Of the Fresh Water SQUILLÆ.

THE Animal whose Figure is exhibited N. iv. Pl. XIV. was brought to me, amongst a Variety of other Insects, in some Water taken out of a Pond communicating with a Ditch at *Kentish Town*, near *London*. The Head and Breast were crustaceous : the Tail and Belly Part were soft, and except the Intestines extremely transparent ; by which means, the peristaltic Motion of the Bowels could be seen with great Distinctness. The Head was armed with a pair of strong Forceps, serrated or toothed near their Base like those of some Spiders, whereby they are the better

better enabled to hold their Prey. A pair of hooked Claws were likewise placed near the Insertion of the Forceps, and became assisting to them. A Snout projecting between the Forceps, having two very short Feelers, and between them a sharp slender Proboscis, could be thrust out or drawn back at Pleasure. Under the Breast and Belly were six Legs, serving either to swim or crawl. It had two pretty large black Eyes: from the Breast to the Extremity of the Tail the Sides were thinly beset with Bristles, and a few Bristles were upon the Legs. The Bowels were seen moving, as plainly as if they had been in a transparent Case, widening their Diameters and rising upwards towards the Breast, and then presently contracting in width and extending downwards: these Motions were alternate; and sometimes the Bowels were stretched almost to the End of the Tail, where the Anus was placed, and there discharged the Faces. It was exceedingly voracious, killing and devouring most of the other Creatures that were in the Water with it.

I take this Animal to be a Fresh Water *Squilla*, of which there are many Species. It was about twelve times less than the Drawing, and therefore must either be of a much smaller Species than I have ever met with, or else a very young one, not yet perhaps come to its perfect State; the Tail be-

ing neither joynted nor scaly as the larger are, some of which I have seen bigger than the Figure before the Reader. I know the *Squilla* change their Coats several times, and perhaps they may also change their Form.

As the natural History of the *Squilla* is known to very few, I shall here insert some curious Observations made thereon by Mr. *Joseph Sparsball*, of *Wells* in *Norfolk*; in a Letter dated *April 6th 1749*.

The following Observations (says he) were made last Summer, whilst I lived at *Wymondham*, on an Insect very common in the standing Waters thereabouts : I think it's the same described by *Mouffet* in his *Theatre of Insects*, by the Name of the *Squilla Aquatica*. — In searching for other Water Insects, I have frequently found these amongst Weeds in Ponds and Ditches, full two Inches and an Half in Length.

The Head of this Animal is broad, flat-tish, and pretty transparent, being very thin in the fore Parts. It has no Mouth, nor does it seem to need any, for it takes in all its Nourishment through a large and strong pair of Forceps, one Limb of which is placed on each Side its Head. These Forceps are hollow almost their whole Length, with a very small Aperture on their Inside ; and when the Creature has seized its Prey, the Juices are conveyed through the Forceps, by two Channels, to about the Middle of the Head ; where
both

both Branches unite and are thence continued to the Stomach. I am the more certain of their receiving no Nourishment but what passes through the Forceps, as I have often by the Assistance of a single convex Glass, and sometimes by the naked Eye only, when the Insect has been sucking its Prey, seen the Juices thereof pass in a fine Stream through the Forceps and Head. This is more particularly visible just after the *Squilla* has cast its Skin; at which Time the Forceps and Head are most of all transparent. Six very small black Eyes are discernable on each Side of the Head, very near the Origin of the Forceps.

Its Body is composed of eleven Joynts or annular Divisions; the Edges whereof slide easily over one another: the last Division is long, tapering and hollow, serving to buoy up the Animal to the Surface of the Water: its Back is hard and of a dark brown Colour, having a paler Streak down the Middle: its Belly is soft and yellowish: it hath six Legs finely beset on each Side with a single Row of Hairs; its Tail is also hairy and divided at the End.

In the Water it generally hangs, suspended by the Tail, from the Surface; the Body arching backwards, so as to make the Belly the convex Part, and the Head inclining upwards towards the Back. In this Posture it waits, like its Fellow Destroyer the Crocodile,

dile, quite motionless, till its Prey is fairly within its Reach; when by a sudden Spring of the Head it seizes it in an Instant, and seldom quits it till it has got its Belly full.

I kept several of these *Squillæ* in Jars during the greatest Part of last Summer, to make Observations on their Manner of feeding; in order to which, I began with giving them the larger Sort of Earth-Worms, which they seized with the greatest Eagerness; and notwithstanding the wreathing and twisting of the Worms for a long Time, they very seldom quitted their Hold, till the inward Contents were quite exhausted, and nothing left but the Skin.

I used frequently, for Want of more proper Food, to give them small Pieces of raw Veal or Mutton, which at first they were very greedy of, but would not eat for above a Day or two together: but whilst I have been giving them a Bit of Meat, they would strike at my Fingers with great Fury, though they were not able to penetrate the Skin*.

One Day I offered one of them a very large Tadpole, and quickly discovered it was its natural Food by the greediness with which
it

* One of these, which I kept some time, was so bold and furious as to attack any thing that was put into the Water; insomuch that I used frequently to divert my Friends with holding a Quill near it, which it would fly at and seize with great Violence, and hanging fast thereto by its Forceps, would suffer itself to be pulled up quite out of the Water by it.

it seized it : and by giving them in large Quantities, I found it would sometimes destroy near twenty of them in a Day, sucking them till all the Inwards were exhausted. Another Time I put a Tench of about three Inches long into a Glass of Water where one of these Creatures was, scarce believing it durst make an Attempt on an Animal so superior in Size : but no sooner did the Tench come near the *Squilla* than he struck at it with all his might, and fixed his Forceps in its Side ; tho' the struggling of the Tench made him quit his hold. A Drop or two of Blood issued from the Wound, and the Fish died in about a Minute : which makes it not improbable, the Bite of this Creature may be poisonous to the Inhabitants of the Waters.

The Bansticle itself, which is so great a Destroyer of the small Fry of Fish, and so well armed for defence, is notwithstanding a Prey to this Devourer ; as I found by putting a very large one into the Jar where I kept a *Squilla*. This Bansticle had lived about a Month in a Jar amongst some Tench, most of which had felt the Effects of his Fury, though three times larger than himself. He was always very lively, and would seldom suffer the Tench to meddle with the Worms I gave them, till his own Belly was full. But on putting him to the *Squilla* he was changed immediately from the most daring to
the

the most fearful Animal ; lurking at the Bottom of the Glass, and continuing there for several Hours together ; neither would he touch the Worms I offered him, seeming perfectly sensible of the Power of his Enemy. However at last, coming within the Reach of the *Squilla*, it seized him furiously by the Back, entering its Forceps on each Side, and after a few faint struggles he yielded to the Conqueror.

Some time after, I put into the same Jar two small Water Newts, of about an Inch and half in Length ; which were both devoured in a very little while. I also put into the same Jar a Water Newt near four Inches in length, imagining the *Squilla* would not venture to attack one of so large a Size ; and indeed at first he seemed afraid of it, but in a few Hours ventured to strike at it: though the Skin of its Back being too thick for his Forceps to enter, he made several unsuccessful Attacks, till seizing it by the Belly he quickly killed it.

These Creatures certainly destroy great Numbers of Fish, and may possibly occasion the Death of many of those that are frequently seen lying dead by the Sides of Ponds, &c. yet they seem more fond of Tadpoles, and are found very large and plump where there is Plenty of them ; but in other Places are generally very small.

I have observed another Species of the *Squilla* somewhat different from the former: they are constantly hunting about in quest of Prey, swimming by the Assistance of their Legs in an Horizontal Position. I put several of both Sorts into a Jar of Water together, but the first described quickly devoured all the last, though some of them were nearly of an equal Size †.

C H A P. XX.

The BRISTLED INSECT.

NUMB. v. *Plate XIV.* represents a small crustaceous Insect which was found crawling on a Brick Wall, *June 30th 1746.* Its general Appearance was somewhat like that of the *Millepes*, *Sow* or *Wood-Louse*; but besides its being covered with Bristles, where-

as

† The chief Difference between these two Sorts of *Squilla*, both of which I am acquainted with, consists in the arming of the Head; which in the voracious Species is furnished with only a strong hooked Pair of plain smooth Forceps, like those of a third Sort shewn in this same Plate N^o xvi. and again more magnified at *fig. S*: but having no Snout between the Forceps as there is at *S*. — The Head of the more gentle Sort is like N^o iv, just now described, having serrated Forceps, and an additional Pair of Claws, (nay in some Species even two Pair of Claws) about the Head to assist the Forceps: These feed on *Pulices aquatici*, and other such small Insects, whereas the first mentioned Species prey on Worms, Tadpoles, Newts, Fishes, &c.

the *Millepes* is smooth, and its having a pretty long bristly Tail, it infinitely surpassed any of that Kind in Beauty. The Coat or Ground was brown, and on that a great Number of indented Bristles or Spines were set, which on its Sides were disposed in Tufts, but on its Back in Rows. They were of a snowy Whiteness, and made so fine a Contrast to the brown Coat whereon they stood, that the whole, when magnified, resembled a curious Piece of Carving in Lignum Vitæ set off with Decorations of Ivory.

This is a rare Insect, of which I don't remember ever to have met with any Description.

C H A P. XXI.

An Insect with Fish-like Fins.

AMONGST some Water and Weeds brought from a Ditch that communicates with the River *Yar*, a beautiful little Animal was discovered, (*May* 9th 1746,) whose Singularity seems well worth describing: and it is hoped that the Figure N^o VI. will give a pretty good Idea of it. The Head was remarkable for two very large pearly Eyes and a Pair of long Antennæ. The anterior Part of its Body had much the Resemblance of some of the Beetle Tribe, and was

was furnished like them with six slender Legs. Immediately below this Part, the Body lessened, and was connected together by seven Articulations, the Part between each Joynt spreading wider at the lower than at the upper End. They appeared all together like the SpinalVertebræ; and from the Procefs of each Joynt issued a Pair of Fins, making seven Pair, or fourteen in the whole. Three other Joynts below the Fins terminated the Tail, the End whereof was ornamented with three long and very elegant Bristles, beset on every Side with short Hairs, and appearing like Plumes of Feathers. The whole Animal was of a faint green Colour, except the Fins, which were as transparent as Crystal. Under each Fin stood out a small Spine; serving either to support the Fin, or as a Weapon of Defence.

Its Motion in the Water was extremely swift, darting itself along at a surprizing Rate: with one stroke only of its Fins it would swim across a Glass Jar it was kept in; but out of the Water it crept as Land Insects usually do. Its Legs were never employed whilst in the Water, and on the Land it made no use at all of its Fins.

This Animal is in its Nympha State, out of which it changes into a small Species of the *Libella* *.

C H A P.

* No. vii. of this Plate was described pag. 321.

C H A P. XXII.

An Insect with Net-like Arms.

AN inquisitive Mind will be inexpressibly delighted with considering the different Forms of living Creatures ; the Changes they undergo ; their several Parts, Members and Organs ; the Manner of their Production ; their various Motions, Dispositions and Ways of Life ; the different Kinds of Food they eat ; their Sagacity, Cunning and Dexterity in procuring it, and the Instruments they are furnished with for that and every other needful purpose. These are Subjects that open the Understanding, and unite every Faculty of a well disposed Mind to adore the Almighty Author of such amazing Contrivance, Order and Beauty. Every thing that lives can furnish out an Entertainment of this Sort : but the larger Animals with which we are daily conversant and familiar, though of a more noble Nature, and immediately necessary to Man ; these, I say, as to the Particulars abovementioned, have not the same Charms of Novelty to gratify Curiosity and recommend them to a strict Examination, as those very minute and almost imperceptible Creatures, discoverable by Glasses only : with any whereof we are hitherto but slenderly acquainted, and of which there
 may

may be probably thousands of Species never seen by an human Eye.

Amongst the smaller Animals, the little Creature I am about giving an Account of, has I believe hitherto escaped Observation; and might perhaps have still continued long unknown, had it not been discovered accidentally, by the same ingenious Searcher into Nature, to whom the Reader is obliged for many curious Articles in this Volume, and whose Description of it I can depend upon, though I have never met with it myself.

In a Letter now lying before me, dated *July* 10th 1746, he writes me Word, that on the 25th of the Month of *May* preceeding, going to the Seat of *Benjamin Nuthal, Esq;* at *Framingham*, in *Norfolk*, he had the Pleasure there of seeing several Cascades, supplied with Water from the Side of an adjacent Hill, and affording a most charming Prospect: and that as he was there attentively observing one of the Conveyances belonging to the Cascades, through which the Water ran extremely swift, he discerned at its Bottom several small Insects, standing erect upon their Tails, and resembling when all together the Combs of Bees, at the Time they are filled with their *Aureliæ*: but on touching them, they immediately separated and dispersed. However he took up many of them in a Bottle with some Water, in order to examine them at Leisure; and looking at them

them next Morning, he found they had formed a great many *Threads* in the Water, much resembling the Webs of Spiders: one of them being taken out of the Bottle with a Quill, it dropped therefrom, and spun a Thread by which it hung, exactly like the common Garden Spider.

He then examined one of these Creatures by a *Microscope*, and was much surprized at the Oddness of its Shape, and the very extraordinary Method whereby it takes its Prey.---The Body appeared as if it had been elegantly turned with a Lathe; being curiously rounded, and gradually swelling and diminishing in several Places; and at the Tail End were three Spines whereon to raise itself and stand upright in the Water; but the most amazing Circumstance of all was the Apparatus about its Head, where there was placed on each side a Kind of Fan or Net-like Machine, serving to provide its Food. *Vid. N° VIII. Plate XIV.*

These Nets (if it may be allowed to call them so) the little Animal frequently spread out and drew in again: and when drawn up they folded together with the utmost Nicety and Exactness, and could be brought so close to the Body as not to be discernable. At the Bottom of these Nets or Fans a Couple of Claws were fastened to the lower Part of the Head; which Claws, every time the Nets were drawn in, conducted to the Mouth of
the

the Animal whatever was taken in them proper for its Food. When the Creature did not employ its Nets, it thrust out a pair of sharp-pointed Horns for its defence, as is shewn at N^o IX, where a larger Figure of the Head and Claws is given, the Diameter being there magnified twenty times, and the Area 400.

These curious Animals were all dead in 48 Hours, notwithstanding fresh Water was given them several times; which then prevented any Opportunity of learning more concerning them, and made my Friend imagine they might be amphibious Creatures, tho' he found them in Water; or might possibly undergo some Change in Form, or Way of living, the Discovery whereof he hoped for at some other Season.

He searched for them after this in the same Place several times, but without being able to find any of them, which occasioned him to conclude, they had either put on another Form, or removed themselves to some other Parts of the Water. However he had met with no Opportunity of looking there for them, at or about the Season when he had first observed them, 'till the Year 1749, when happening to be near the Cascades on the 21st of *May*, he determined to try his Luck once more, and then found, with little Trouble, many of the very same Animals, in the most rapid Part of the Cas-

cade where he had seen them first. He carried several of them home very carefully in a Phial, but in two Days most of them were dead, and the rest having spun themselves thin transparent Cafes, (which were fastened either to the Sides of the Glass, or to Pieces of Grass put into the Phial with the Water,) became changed into what he supposes a Kind of Chrysalis, of which a Front-View is given N^o XI, and a Side-View N^o XII. But before their taking this Form, he perceived them sometimes in another Shape, different from the first described, and such as is shewn N^o X; which, he says, was the Figure they appeared in, when they were weary with catching their Prey, or lay in wait for it.

None of them lived more than three Days: and 'tis remarkable, that notwithstanding fresh Water was given them two or three times a Day, yet in a few Hours it would stink to a Degree scarce conceivable, and that too at several Yards Distance, tho' in Proportion to the Water all the included Insects were not more than as 1 to 1,150,000. ----- How exquisitely subtile and minute must the Effluvia from the Bodies of these little Animals be, that can so soon and so strongly infect such Quantities of Water and Air? This perhaps makes it necessary for them to live in a rapid Stream, lest they should be poisoned with their own Perspiration,

ration, as perhaps they were in the Glass Phial.

The largest of them exceeded not $\frac{1}{10}$ of an Inch in Length and $\frac{1}{30}$ of an Inch in Diameter : they seemed rather soft and fleshy than crustaceous, and their Colour was a Kind of yellowish grey.

C H A P. XXIV.

Insects found on the Bark of the Ash.

AT the beginning of *February* 1748-9, I received from the same curious Person two Pieces of the Twigs of an Ash Tree, (just cut when they were sent) of about half an Inch in Diameter. Each of these had one of its Sides covered thickly from End to End with Numbers of little Spots, not larger than very small Pins Heads, and rather long than round. Their Colour was somewhat different from the Bark on which they were placed, and an attentive Eye could perceive they rose a little above it. On crushing them, a Liquor red as Blood issued out ; and each Spot, when examined by the *Microscope*, was found to be of a silky Substance, adhering closely to the Bark, and serving as a Covering or Nest to 30 or 40 *Ova*, which on removing this Covering with the Point of a Lancet presented themselves to View ; much resembling

sembling the *Aurelice* of *Ants* in Shape, but a thousand times more minute, and of a beautiful scarlet Colour.

This Discovery excited a strong Desire of learning what kind of Animalcules these little *Ova* would produce ; but those in my Possession never came to any thing, being I suppose deprived of a due Degree of Moisture by the Drying of the Twigs. My Friend's Diligence however supplied this Defect : for sticking a Bough covered with them into the Ground, in his Garden, in a warm Corner where the Sun could shine freely upon it, prodigious Swarms were hatched of beautiful little Insects of a fine Scarlet Colour, whose Figure is given N° XIII.---O.--Their Back is something like that of the *Wood-louse* or *Sow*, and in other Respects they differ not greatly from that Animal in Form : but are armed with a large strong pair of Forceps, which the *Wood-louse* has not.

'Tis a pleasing Entertainment to see them creep out of their silken Cases or Coverings, at an Opening in the Cases at one End, left there probably for that purpose by the Parent Insect, when she wove this Integument over her little Brood to preserve them from Injury ; in like Manner as many Sorts of Catterpillars leave Openings, or a much looser Spinning at one End of their Pods, through which after their Change they may be able to come forth. See N° XIII.

And

And it is worth remarking, that every single Insect, besides being inclosed in this Covering of Silk, which is common to 30 or 40 of them, has a pure white transparent Case or Shell, which being left by the Insect nearly resembles the Shape of an Hen's Egg : and if they are not disturbed at the Time of hatching, most of their Egg-shells will be found empty under the common Coverture. And by attending to them a little, one shall see, at the same time, several of these Insects hatched, some just breaking out of their Shells, and others creeping about with their Shells hanging to their Tails, as at N^o XIII.

My Friend's Account says, that the largest of these Animalcules measured little more than the 114th Part of an Inch in Length, and the 200th Part of an Inch in Breadth ; and consequently the Number of them required to cover a superficial Square Inch would be something more than 22800*.

His Method of finding their Magnitude was as follows. — In order (says he) to be certain of the magnifying Power of the Glass I made use of, (which was the third Magnifier) I divided a Line, drawn exactly an Inch in Length on a Slip of ground Glass, into 20 equal Parts. Then placing this Slip of Glass under the Microscope, I threw the magnified

B b 3

* This is the least Insect I have observed produced out of the Water.

fied Image of one of these 20th Parts upon a Scale of Inches seen by the naked Eye, (according to Dr. *Hooke's* Method †) and found it coincide exactly with 4 Inches : and consequently that the Glass magnified 80 Times.

Then taking my divided Inch from under the Magnifier, in order to make use of it in the same Manner as I before had done of the Scale of Inches, I cast the magnified Image of one of these Animalcules on my Scale of Twentieths of an Inch seen only by the naked Eye, and found its Length to cover 14 and its Breadth 8 of those 20th Parts of an Inch. --- But the Measures of $\frac{1}{20}$ ths and $\frac{8}{20}$ ths being only the apparent Dimensions, they must be divided by 80, the magnifying Power of the Glass, to give the real Size of the Animalcule, which will then be found to be $\frac{1}{1600}$ in Length, and $\frac{8}{1600}$ in Breadth: which Fractions reduced to their smallest Denominators will be $\frac{1}{800}$, (nearly $\frac{1}{14}$ th) and $\frac{1}{200}$: or taken decimally, $\frac{1}{10000}$ th, and $\frac{8}{10000}$ th Parts of an Inch.

C H A P. XXV.

The LOUSE of the CARP.

THE Animal shewn at N^o XIV. *Plate XIV.* was found, with several others of the same Kind, sticking to a large Carp, just

† See this Method explained in *The Microscope made easy*, pag. 45.

just taken out of the *Canal* in *St. James's Park*. It was about one Tenth of an Inch long, and nearly as much in Breadth at the broadest Place. Its Back was covered with a Shell, (or rather pliable Scale) of the Figure represented in the Drawing: this Shell was so extremely transparent, that the finny Legs, of which it has four Pair, besides two shorter Claws, might be seen almost as clearly through it as if they had no Covering; and on each Side the Body of the Animal, at equal Distances therefrom, were many curious and beautiful Ramifications, somewhat opake, extending a considerable Length, and seeming either to be Blood-vessels, or muscular Processes connecting the Body with the Shell.

The Tail was a Kind of scaly double Fin, not unlike those at the Extremity of a Lobster's Tail, but exceedingly transparent, and each Half or Fin was marked with one single black Spot, as in the Plate.

The Eyes (which for the Sake of shewing them to more advantage are greatly magnified at *fig. K, 1. 1.*) were very singular in their Structure, being neither smooth single Balls, like those of most Quadrupeds, Birds and Fishes; nor pearly Balls like the Eyes of many Insects; but in this Animal each Eye was composed of a globular Body, almost incircled round with smaller Globules, as the Drawing represents.

Between the Eyes appeared two pair of short strong Spines, one pair whereof pointed forwards and the other backwards: I know not whether these served as Feelers, or were Weapons of Defence or Offence. At a little Distance below the Eyes were placed two large cylindrical or rather somewhat conic Suckers, composed of several *Annuli*, seemingly like those that form the Windpipe in Birds and Beasts. The Animal, by means of these, adheres and fixes itself so strongly to the Fish it preys upon, that all the Motions and Efforts it can use are insufficient to shake off the little Tormentor, who is continually feeding on and making it uneasy. See the Suckers *fig. K. 2, 2.* Just below them at 3, and above the grand intestinal Duct, lay the Heart, composed of two Lobes, which might be seen to contract and dilate alternately, as the Hearts of many other minute aquatic Insects do.

One of the short Fore-claws, which is covered with a strong Shell, and armed with three Hooks at its largest Joynt, is shewn *fig. L.*

This little Creature makes a very pretty Appearance in the Water, where it is continually playing up and down, with a Kind of hovering Motion, like that of the *May-Fly* in the Air. Sometimes it leaves the Fish, to divert itself for a while in such Manner, and then settles on it and fixes itself again.

again. The internal Motions of the Bowels, &c. are presented so finely to Observation, by the uncommon Transparency of its Shell and Skin, that it is a most agreeable Object for the *Microscope*; and the Carp is often pestered with such Numbers of them, that they are not very difficult to procure. They may be kept a long while with the Carp in Water, but unless the Fish be with them they die in a Day or two.

The natural Size of this Insect, at its full Growth, is something less than one of its Eyes appears in the magnified *fig. K.*

C H A P. XXVI.

The Louse of the Banstickle, or Prickleback.

NUMB. xv. is the Picture of the little Vermin that infests the *Banstickle* or *Prickleback*; whereto it adheres so firmly that it is hardly possible for the Fish to get rid of it, unless it pleases to unfix itself. It is furnished with a pair of sucking Instruments like the *Carp-louse*, has the same Number of Legs or Fins, which are continually in Motion whether it be swimming or fastened upon the Fish: and in most other Particulars it so nearly resembles the said Animal, that after taking notice of some
Difference

Difference in Shape, which the Picture may serve to shew, nothing more need be said about it.

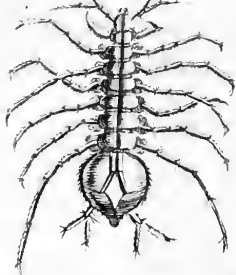
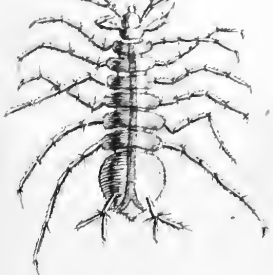
The Long-snouted SQUILLA, &c.

SEVERAL of the Insects shewn N^o XVI. were sent to me from *Yarmouth*, in a Bottle of very clear Water. Some were about a Sixth Part as big as the Picture, and others a great deal less, but none of them alive: having either been suffocated by corking the Bottle too close, or shaken to Death in bringing. They seem to be of the *Squilla* Kind, tho' a Species I have never seen before or since: but the Numbers that were sent make me imagine they are frequent in those Parts.

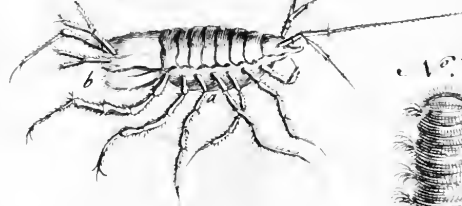
The Back is crustaceous, and joynted like a Lobster's Tail; having ten Articulations, which divide it into eleven Parts, the middlemost of which are widest; for they lessen from thence to the joyning on of the Head one Way, and grow tapering the other Way to the Extremity of the Tail, which ends almost in a Point, with a Sort of a Horn on each side, that extends beyond the Tail. The Scales of the Back reach down the Sides, and meet the upper Part of the Belly, beyond which they stretch out and over-hang a little. The Belly is softer than the Back,
and

Animalcules.

A^o II.



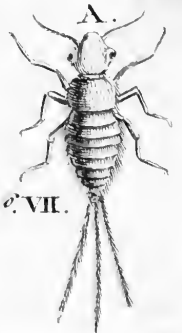
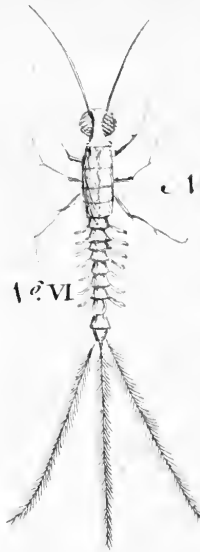
A^o III.



A^o V.



A^o VII.



B.



A^o VIII.



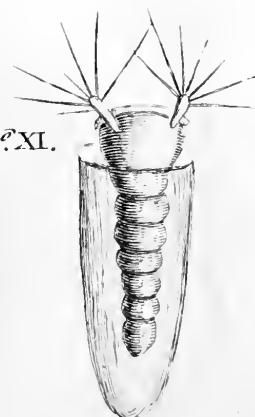
A^o IX.



A^o X.



A^o XI.



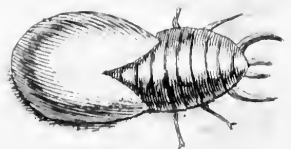
A^o XII.



N.



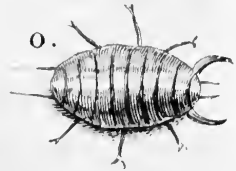
A^o XIII.



M.



O.



A^o XIV.



Fig. K.

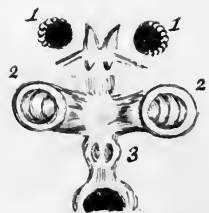
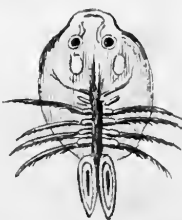


Fig. L.



A^o XV.



A^o XVI.

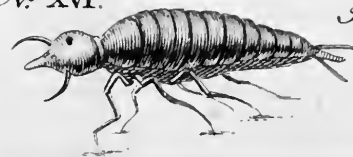


Fig. S.





and from its anterior Part proceed six Legs, on each side three, joynted in an odd Manner, and seemingly but awkward for walking with. But the most extraordinary Part of this Animal is the Head : a Draught whereof, magnified a great deal more, is given *fig. S.*-- This Head is armed with a pair of very sharp hooked Forceps ; between which it is lengthened out into a Sort of Proboscis, whose Shape resembles a Duck's Bill, and under that the Forceps can occasionally be brought together, or even cross each other, in order to secure its Prey. However, this Proboscis did not divide nor open like a Bill or Mouth, neither could I discover that it had any Perforation : which makes it probable, that the Creature sucks in its Nourishment intirely through the arched Limbs of the Forceps, in the same manner as the *Squilla* described *pag. 358.* And indeed our present Subject differs little from that voracious *Squilla* (which I take it to be another Species of) except in having a Proboscis ; whereas in that the Forepart of the Head between the Forceps is remarkably short and flat †.

The Figures M and N, in this same Plate, are two Views of an Animalcule, many of which were discovered in Water that had been kept in a Glass Jar for some Months.--
It

† Supposing the Proboscis away, the Drawing N^o xvi. will give a pretty good Idea of the *Squilla* *pag. 358.*

It is shewn at M in the Posture of swimming, at which Time it moves pretty swiftly with its flat Head foremost : its Tail appears divided, and on each Side it extends a spreading Fin. At N it is shewn in Profil, and with its Fins drawn in, as usually is the Case when it appears at rest.

'Tis about the Size of the largest Animalcules found in the Infusions of Hay in Water.

C H A P. XXVIII.

A Letter from a Friend, containing many curious Microscopical Observations, &c.

MANY of the Drawings in *Plate XV.* together with the Descriptions of them, were sent me by a Gentleman, whose true Judgment in the Use of the Microscope, and the Accuracy of whose Pencil in delineating therefrom, I have been long acquainted with ; and whose Name, had I leave to mention it, would do great Honour to this Work, as his Friendship does to the Author of it. As it is therefore necessary to give his Description of these curious Subjects in his own Words, I hope it may be excusable to publish the whole Letter wherein they are inserted, though written with the kind Partiality of a Friend.

S I R,

S I R,

I Am glad you are determined to publish your *Microscopical Observations*. There are few who have been able like you, to gain Access to the *Sacrarium in quo reducta et clausa sunt arcana Naturæ*; fewer still who have Capacity to smooth the Path for others, and render the Examination of Nature by the Microscope easy, short and pleasant: This you have done, and thereby have acquired a Title to the Observations which by your Book others have been enabled to make. What I send you are therefore of right your own. They have suffered indeed by not being under your Eye; their Defects are mine; what Worth they may have must be ascribed to the Assistance of your printed Directions for the Use of the Microscope.

You desire to add to your proper Observations, such as have been occasionally made by your Friends: and as I am so happy as to be one of that Number, I shall here communicate what has occurred to me; perhaps of very little Consequence, but as *rerum Natura sacra sua non simul tradit, nec omnibus illa patent*, the following Observations may have the Recommendation of Novelty in some Degree: and those that are not intirely new I send to you, because they tend to correct the imperfect or incompleat Observations already published.

The

The Drawings I made myself, when the Objects were under Examination, with Mr. Cuff's Microscopes, and as exactly as I could: and his Glasses are so excellent, that if there should be found any Defects in the Figures, they must be attributed to my Inaccuracy and Difuse of Drawing. However, such as they are, they are at your Service.

If these Things shall appear insignificant, yet as in complying with your Desire to have them, they afford me an Opportunity of shewing my Regard and Friendship for you, they are grateful and valuable to me.

I shall first give you an Account of what I have met with in Respect to Water-Insects, which have, formerly, in many Instances, been thought imperfect in their Production, from the Imbecility of the Element to which their Creation was attributed: for aquatic Insects may certainly be comprehended under *Animalia aquatica*, which *Seneca* calls, *tarda et informia, ut in aere caeco pinguique concepto*. But Attention to the Works of God makes manifest, that the Heavens do not alone declare his Glory; — *Jupiter est quodcumque vides*. And indeed whoever searches the Waters will not find his Curiosity disappointed; there he will see the Works of God displayed to those who delight in them; and perhaps with greater Variety and more Profusion than in any other Element.

Fig. 1. Plate XV. is an aquatic Insect of which we have two Drawings and Accounts, both very short ; one in the *Phil. Transf.* 288, the other in the Letters of Mr. *Leeuwenhoek*, *Epist.* 121 : and as this Insect has no Name, I will venture to call it the *Pediculus aquaticus* ; for the Insect to which *Goedart* gives that Name, is now allowed to be the *Pulex arborefcens*, or *arboreus* of *Swammerdam*. This Insect is a common one, and of the crustaceous Kind, but being pretty transparent it is a beautiful Object in the Microscope. When it is swimming it appears as *fig. 1.* It has five pair of Legs ; the first pair on the Side of the Head are the longest it has, the four other pair are short and upon its Belly : the first and second pair are only visible as it swims. The Back is guarded with large Scales which proceed all the Way to the Tail, but from the eighth Scale they are frequently covered so thick with Hair, that only the Joynts or Divisions are discernable ; but in other Postures, as in N^o 3. the Scales are visible all the Way to the Tail. — The Tail is divided into two, with Hairs issuing from the Extremities of each Division, which in swimming are kept extended, as in *fig. 1.* The Colour of this Insect is a pale brown.

Fig. 4. shews the Insect upon its Back, when all the Legs were visible ; only the three

three lowest pair were laid back upon its Body, and kept in a constant Motion among the Hairs which cover its Belly, as if brushing itself. Nearer the Tail appear two Bags or Paps, hanging down, with a round Part at the Extremities, set with a few Hairs. I at first imagined these were the Receptacles of its Spawn, but have since found the Spawn placed much lower under the Tail : so that if this be the place of the Spawn in the particular Insect these Drawings were taken from, there may be different Species of these Insects.

Fig. 3. is the same Insect reclined on one side, when the Scales are most conspicuous as they unite ; eight of its ten Legs are visible, and only one of the Paps appears hanging down.

It is said in the *Transactions* that this Insect is *monoculous* ; and indeed it is not easy to discover its Eyes ; they are placed in the middle of the Head between the first pair of Arms, and appear as in *fig. 2.* But it has two Eyes joyned at the Bottom, both conical, and apparently separated towards the Vertices as at *fig. X.* which shews these Eyes greatly magnified. When the Head of the Insect is bent down, they may easily be mistaken for one Eye, as is evident from their appearance in *fig. 3.*

Mr *Leeuwenhoek's* Painter has given Us a very bad Figure of this Insect ; his Account mentions

mentions the Manner of its carrying the Spawn. In *fig. 2*, towards the Tail, the Spawn Bags (at least what I believed such) were more extended than in any of the other Figures, but no Spawn was discovered in them; and since these Drawings I have examined more of the *Pediculi aquatici*, and find the Spawn fixed to the Tail much lower than those Bags, and adhering to the Tail by two fine Ligaments, which are easily broke by the Insect's stirring itself in the Water; and sometimes all the Spawn comes away sticking together, but oftener separated and dispersed among the Water. But though I have kept the Spawn some time, I never could find the young Insects in the Water, which *Leeuwenhoek* speaks of; but perhaps I have not had mine when the Spawn was come to an equal State of Maturity. I have sent you this Account, because the former Figures of this Insect have been extremely imperfect in all respects, except the Spawn, which in Mr. *Leeuwenhoek's* Drawing is exact enough*, and also as I found the Opinion received that this Insect varied from all others in being *monoculous*.

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* From finding this little Creature very frequently with its two Bags of Spawn adhering to its Tail, (as may be seen *Plate IX. fig. II.*, of the *Microscope made easy*; in the Drawing there, taken from Mr. *Leeuwenhoek*,) I have been accustomed to call it the *Bag-Animal*.

The two *Figures* 5 and 6 are I believe only different Appearances of the same Insect, altho' there is some Variation in the Make of the Shells, but in all other Respects they agree. I at first took this Insect for the *Pulex arborefcens* and certainly it may be classed with it: but comparing it with *Swammerdam's* Figure, it by no Means agrees therewith, nor with that which you shewed me †; for in this there are four *Brachia ramosa*, in the other only two; these here are lower, and proceed from the Insect under the Shell, the others are on each Side the Head and from the Shell. This Insect has two *Antennæ*, and that has none, but a Bill like a Bird's. — I have drawn these as they appeared swimming with their Backs to the Eye, where the joyning of the Shells is visible, which seemed ridged or marked with black Streaks as in the Figures: the Colour was a deep brown.

In some Pond Water with the *Lens palustris* I found the Insects of which I sent you the *Drawings* fig. 7 and 8. The first of these, fig. 7, was contained in four very thin transparent Shells. The two upper Shells united on the Back, and declined down the Sides till they met with two under Shells, making at the joyning of the Sides acute Angles,

† The Figure here mentioned may be seen *Plate XII.*
fig. 14.

Angles, and at their joyning on the Back and Belly obtuse Angles ; but the upper Shells projected beyond the lower, which appeared beyond the upper towards the Tail, and probably by this means these upper Shells served the Insect instead of Fins, and to keep it up in the Water. All the Shells were elliptical.

The Figure represents the Insect swimming, when the Head appeared beyond the Shells without any Antennæ or Feelers: the Tail was divided and extended : the Body was very apparent, and that Part which is on the Back in the Middle was in a constant Motion, alternately contracting and dilating. From each side below this Part there appeared a Ligament, terminating at the Circumference of the upper Shells, and may perhaps serve to keep the Shells steady, or to move them, if they be moveable; which I could not discover, for the Motion of the Insect is very equable and smooth.

Fig. 8. is an Insect which I am apt to believe is the same as *fig. 5.* in another Posture, as it stands feeding in the Water : for it agrees in Colour and in the Shell exactly: the Antennæ and Arms have as near a Resemblance as can be expected in such differing Positions. It has indeed two Legs behind, wherewith it fixes itself to the Glass, which do not appear in the other ; but if they are only to fix itself, they may be covered under

the Shell when swimming: however there is some difference in the Appearances. This Insect swims well and nimbly, and by a rapid Motion of its Arms makes a strong Current to bring it Food: (which Manner of feeding by a Current or an Eddy is common to many other Water Animals:) indeed, the Swiftneſs with which it moves not only the two Arms that are extended to draw Things to it, but alſo thoſe that are bent back, to drive along each ſide what is not fit for its Food, and the Way they co-operate all together to make a ſtrong Stream, is inconceivably curious, as well as its Conſtancy and unwearied Application. When it is diſturbed it draws itſelf intirely into the Shell, and then appears not unlike a ſmall freſh Water Muſcle.

The Inſect *fig. 9* is very uncommon: I never met with any more of the Kind, nor with any Account of it. At firſt, when I found it among ſome Water in a leaden Ciſtern ſtocked with the *Nymphæ Vermiculi* of the Gnat, I fancied it might be the *Vermiculus* of that Inſect; eſpecially as the Head was not very unlike it, and it had pulmonary Tubes towards the Tail, as the *Nymphæ Vermiculus* has one. But as it never changed its State during three Weeks that I kept it alive, though the Gnats changed much ſooner, and it has many different Parts from
those,

those, I must own I know not what Insect it is, or what State it is in.

The natural Length of this Insect was $\frac{1}{4}$ th of an Inch, and its breadth at the Shoulders or broadest Part $\frac{1}{20}$ of an Inch, according to the most exact Dimensions I was able to take. Its Colour was a pale red or pink, which appeared deeper at the joyn- ing of the Rings, but transparent. The Head was covered with a Shell, of a light brown, with two small Eyes set round with Hair, as was also the Mouth, or at least that Forepart of the Head on each Side of which it had the Antennæ bending inwards; but without Hair or any Joynts between the Shell of the Head and the first Ring of the Body; the Neck part which appeared being a Continu- ation from the Head. Its Body consisted of eleven Rings, tapering something all the Way to the Tail, but the two first and three last Rings not so wide as those in the Mid- dle. Under the first and second Ring it had two Legs, (of which one only could be re- presented in the Figure) and their Extremi- ties were set round with Hairs: between the tenth and eleventh Ring two small Tubes arose, making an obtuse Angle with the Forepart of the Insect's Body, but an acute Angle with each other: the Ends of these Tubes were set round with Hairs and seemed to be open: I take these to be pulmonary: not that the Insect always kept them upon

the Surface of the Water, though it often brought itself up till they were there, but because in other Insects such like Instruments of breathing have been observed.

From the eleventh Ring the Tail begins; which is represented as it appears when the Insect uses it for swimming, and the whole of it is most visible. It does not however keep it in this Posture when swimming, but alternately extends it on each side and brings it together again as Men do their Arms in swimming. The Ends of each Branch of the Tail are set round with Hairs, and there seems to be a Joynt in each; but the Drawing will give you a better Idea of it than any Words. --- I must not however omit saying something of its Intestines. On each side there is a small Vessel running from the Head to the Tail, in which a constant Circulation of a pellucid Fluid was discernable: from the second Ring to the fourth a dark coloured Vessel appeared, with the End next the Head seemingly open, or if covered, it was with a light coloured circular Tegument. This Vessel terminated in a fine Canal that seemed to enter another Bag of a clear white Colour, at whose End was a Gut or Canal that went quite down to the Tail. This Bag or Vessel I conjectured might be its Stomach. Above this Gut, and at the seventh Ring, began another Vessel or Ligament, I can't tell which; reaching (after crossing itself twice)

to

to half the tenth Ring, and there ending abruptly, without communicating with any other Part ; so that unless it be an Instrument for contracting the Body of the Insect in walking along the Bottom of the Vessel it is in, it seems only a Provision for some other State it is to assume.---I forgot to observe, that when the Insect swims it uses also its Fore-legs, bringing them up close under its Head, and moving them back close under its Belly.

If I could have found any more of this Kind, so as to have ventured killing it, by viewing it in the Solar Microscope I might have given you a fuller Account of it, especially of the Intestines : but as I was curious to discover what Changes it might undergo, I was very tender of it : however I was disappointed, for it died after I had kept it three Weeks from the 5th of *September*, and in a Week after it was gone to pieces, so that I could not bring it to Town, to shew it you as I intended.

Fig. 10. the only one of its Kind I have ever seen, is an Insect called by *Monsieur de Reaumur* le Vers a queue de Rat, *the Worm with a Rat's Tail*, of which he has given an accurate Account, *Mem. ii. Vol. 4.* of his excellent *Memoires*. It is it seems the Vermiculus of a Fly with two Wings †; and if I

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had

† It changes to a sort of *Gad-Fly* or *Breeze*; about the Size and Colour of the *common Bee*, but having only two Wings; the Tail Part broad and flat, and without any Sting.

had had his Book when this Insect was found, I should have made freer with it than I did, and not have preserved it to observe its Change of State. The Drawing of it I send you, and for an Account of it refer you to *Monsieur de Reaumur*.

This Insect was found in a Cistern of Rain-Water in *August*. The Length of its Body was $\frac{1}{2}$ of an Inch, but its Tail was four times the Length of the Body, though not extended near so far as it was capable of being. Above Half of the Tail was covered with a fine Down, in small circular Divisions, as the whole Body was: this Down or soft Substance is of a fine reticular Make, and at the Head there appeared two Antennæ within the outward Coat, which the Insect by means of these Antennæ spread out or dilated at Pleasure: so that the downy Covering seemed not so properly part of the Insect as to contain the Insect. There were Fibres visibly crossing upon the Back, and running down to the Tail: And near the Tail, between these, a Vessel of a black Colour appeared, growing gradually less to the Extremity. The Colour of the Insect was a pale Ash, the Tail and Antennæ black, the Extremity of the Tail set with Hair.

I take this Insect to be the same with the Rat-tail'd Insect of *Monsieur de Reaumur*, but by the Figure you will see it does not in all Respects agree with what he has described: perhaps

perhaps the Flies of which these are the Worms, or the Nymphæ, may vary in *England* from those in *France*, where certainly they are more common than here. The principal Difference is in the Legs, of which this had only six pair, his seven: the Ends of them were set round with Hairs, and just under the Tail was a singular Fin, double, joyned at the lowest Part in an acute Angle, and from thence growing smaller 'till it came to the Body. By means of this Fin, as a Rudder, it steered itself in the Water, on the Surface of which it kept the Extremity of its Tail: and when Water was added, it lengthened its Tail as much as it could: and if that did not reach the Surface, it raised itself higher, exactly as *Monsieur de Reaumur* observes, and about the same Length, (near five Inches,) before the Insect was obliged to leave the Bottom of the Glass,

I shall now describe an Insect not found in Water, and very common in Time of Harvest, but of which I have never seen any Drawing or Account. It is called the *Harvest-Bug*: is of a bright red Colour: so very small as to be imperceptible to the naked Eye, and on the Point of a fine Needle resembles a Drop of Blood. A Drawing taken from the Insect preserved in a Slider, and greatly magnified, is given *fig. II.*

I had often heard of these Insects, but did not give intire Credit to what I heard, 'till a

Lady taking this out of her Neck convinced me of their Existence and Taste. They are extremely troublesome to those that walk in the Fields in Time of Harvest, especially to the Ladies, for they know what Skins are finest and easiest to pierce. They have at the Head a Proboscis near $\frac{2}{3}$ of their own Length; by which they first make way through the Skin, and then bury themselves under it, (leaving no mark but a small red Spot) and by their sucking the Blood create a violent Itching; a good Remedy for which is a little Hungary Water; though perhaps Spirit of Wine with Camphire might be more destructive to these little troublesome Attendants of Summer Walks. They are I believe frequently carried in the Winds at their Season, for I have since known them attack Ladies in a Garden, which was defended from a Corn Field by a Wall, too high for these Insects to get over any other Way.

They have three Legs on each Side, with four Joynts set with Hair, as the Body is all round. The first pair of Legs arise from the Back, just below the Eyes: the other two pair from the Belly: it has also two short Antennæ, one from each Side of the Head, which appears with a Division in the Middle. I have sometimes suspected this little Creature might be a young Sheep-Tick, from its Figure and Way of burying itself: but then it should be found rather where

Sheep feed than in Fields of Corn, growing, and before Sheep are suffered to come into those Fields : and it is never got as I have heard in Grass Fields, unless bordering upon Corn ; but amongst Wheat it never fails. If any one has a mind to make Trial upon this Insect, how it comes to be amongst Corn only, and yet lives by sucking of Blood, he may easily find Abundance of them : for though they prefer the Ladies, yet they are so voracious, that they will certainly lay hold of any Man's Legs that comes in their Way.

I intended to have sent you an Account and the Figure of the young Plant found in the Kidney Bean, but as that has been already accurately observed by Dr. *Grew* in the *Anatomy of Plants*, I need not trouble you with it : I shall therefore only take Notice of the Seeds of two other Plants which have not hitherto been observed, as far as I know.

In the Seed of the Lime Tree, which arises from a Stalk in the Middle of the Leaf, (as represented N^o I. *fig.* 1.) there is a young Plant to be found, when the Seed is ripe, towards the Beginning of *October*.

The Seed of the Lime Tree is covered with a rough Skin, within which there is a Shell, but not hard ; if this Shell be carefully opened there will appear a thin white Juice, inclosing six Pods or Bags, all tyed together, and adhering to that End of the Seed which is joyned to the Stalk, with very fine Fibres running

running up the Inside of the Shell, and appearing as *fig. 2.* These Pods when taken out of the Shell appear as *fig. 3.*

As the Seed advances in Maturity this white Juice grows harder, 'till it is quite ripe, and some one of these Pods has robbed the rest of Nourishment, by taking place within the Kernel, where it expands and excludes the rest, which will now be found sticking to the outward Cover of the Kernel dried to a brown Colour, with their Fibres embracing the Kernel, serving only as Cords to keep the Nourishment of their more fortunate Brother together, and appearing as *fig. 5.* So that if we follow the Opinion of *Swammerdam* and *Voltaire* in his *Metaphysics* of *Sir Isaac Newton*, pag. 54 of the English Translation, that we see in Things a *Disenvelopement* only, here the Author of Nature has provided in one Seed six *Vermiculi*, one of which alone is to become a *Nympha Plant* : for I never met with any Seed which contained more than one young Plant, in that State, which under *Voltaire's* Authority, I may venture to call the *Nympha State*.

When the Seed is come to a sufficient Consistence, and ready to drop from the Tree, if it be opened it will appear as *fig. 4* : the inside filled with a white shining Substance inclosing a deep green Plant like a Flower, which arises by a small Fibre from that Part of the Seed to which the Stalk adhered, and perpendicular

perpendicular to it. The Plant when taken out, and viewed in the Microscope, appears as at *fig. 6*. All the Fibres of the Leaves are discernable, altho' the Leaves are themselves thicker in proportion than those of the Tree, and seemingly turgid with Juice. These Leaves are double, and so tender and soft that I could only with the finest Needle separate them a little towards the Top, as I have endeavoured to represent in the Drawing.

N^o II. is the Seed of *Asparagus*. -- *Fig. 1.* is the red Berry as it grows from the Stalk, which contains, in a soft watry Pulp, six black shining Seeds, formed as I have tried to represent at *fig. 2*. Their Appearance, which ever way you view them, represents that Shape which *Bellini* calls *Pelecoides*. Each of these Seeds contains a hard white shining Substance with bright small Specks all over it; and, lying horizontally, a small Plant, white indeed but with a yellow Cast, plainly different from the Parenchyma in which it is situated. This Plant examined in the Microscope appears as *fig. 4*, with bright Spots like *Papillæ* all over it, and the bending Leaf at the Top tending to a faint green. When the Plant is taken out the Section of the Seed appears as *fig. 3*, in which the Bed of the young Plant runs quite through the Parenchyma, from one Side of the

the Covering or outward black Film to the other.

Altho' I shall endeavour to follow the learned Mr. *Hook's* Advice to those who should correspond with the *Royal Society* : " to send the Kernel of Fact stript from the " Shell of Impertinencies," yet you will give me leave to observe two Singularities in this young Plant of the *Asparagus*. *First*, that its Position in the Seed is very different from most others : this lies horizontally, and not perpendicular to the Juncture of the Stalk, as others generally do ; and indeed though I have seen many Seedling or Nympha Plants, I never met with one posited as the *Asparagus* is. *Secondly*, it has no Fibres or Ligaments communicating with the Seed in which it is inclosed, but lies in it as a Nidus, adhering only by filling the hollow Bed exactly.

I have now given you an Account, and I fear a tedious one, of some things unobserved before, I believe, which have occurred to me : from your Friendship I am persuaded I need make no Excuse for it ; if I was to make one, *Pliny* the elder (*et ille etiam Causas agitavit*) shall tell you my Sentiments as well as his own, *inter crimina ingrati animi et hoc duco, Naturam ignorare.*

I am, Sir,

Your sincere Friend and most

humble Servant.

Of luminous Water INSECTS.

IN my former Treatise on the Microscope, I took Notice of the *shining Light* frequently found on the Shells of Oysters, as being produced by three Sorts of Animalcules, which are there described, according to the Account given of them by *Monseur Auxaut* †. I had then no Opportunity of adding any Figure to that Account : but having not long ago been favoured (by a Friend whom I can depend on) with the Description and Drawing of one Sort of Animalcule, which he had observed to occasion such Light, I shall insert it here.

Having (he says) been sometimes surprised at the Sparks of Light to be seen on the Shells of Oysters, on removing them, or striking on them, when newly taken from the Sea ; he bestowed some Pains to find out the Cause ; and after many Examinations became perfectly convinced, that these shining Sparks are lucid Emanations from a minute Insect, differing in its general Form but little from the common *Scolopendra*. This Insect he carefully made a Drawing of from the Microscope, an exact Copy of which is given

† Microscope made easy, third Edit. pag. 241.

given at Letter A. --- Its Length was about the $\frac{1}{8}$ th and its Breadth rather more than the 100th Part of an Inch.

The Body consists of twenty-eight Joynts or Divisions, exclusive of the Head and Tail Parts: each of these Divisions has a pair of Feet belonging to it, (viz. one on each side) making the whole Number of its Feet 56, or twenty-eight pair: they are all short and beset with Hairs.

The Tail Part is larger than any of the other Divisions, and has three pretty long Spines or Bristles proceeding therefrom. The Head is remarkable, on Account of its being armed with a pair of Forceps uncommonly long and large in proportion to the other Parts: beginning much farther backwards than is usual in other Animals, and reaching beyond the anterior Part of the Head, in a Manner very convenient for seizing its Prey and carrying to the Mouth any thing it takes hold of. It is furnished with a pair of Horns, and has besides at the Snout two short Antennæ or Feelers.

This little Insect can emit or conceal its Light: and sometimes its Lustre is so bright as to be discoverable even in open Day-light, especially on being touched or disturbed*.

Its

* The Rev. Mr. *Thomas Harmer* of *Wattlefield* in *Suffolk*, sent a Sea Insect to a Friend, who gave it me, preserved in Spirit of Wine. The Account Mr. *Harmer* wrote with it

Its Light is blewifh like that of the Glow-worm, or a Spark of burning Brimftone.-- My Friend obferves, that our fmall Land *Scolopendra* has likewise the Property of fhining in the Dark, which indeed has been taken notice of long ago. *

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fays, that opening Oysters he found this Animal between two Shells which ftuck together. It was alive, but faint. Perceiving it emitted Light in the Shade, he carried it to a dark Place, where by irritating it on the Back with a Pin it fhone pretty ftrongly more than once. The Light appeared on its Back towards the Tail, chiefly in two Spots; but, when more violently irritated, it was fometimes feen darting along the Back; and, particularly once, it was illuminated in Streaks up to its very Head. The Infeft growing more languid, he put it, between the Shells where it was found, in fome Water wherein Salt was difsolved, hoping it might revive; but in an Hour it was quite dead. — 'Tis about $\frac{3}{4}$ of an Inch long, and $\frac{1}{5}$ of an Inch in Breadth; in Figure flat, with many Fins along its Sides from End to End.

* *Mouffet* writes, that his Friend Mr. *Brewer*, found twice, by Night in the Summer Season, amongst Heath and Mofs, the fhining *Scolopendra*, lucid and fiery: its whole Body emitted Light, but fomewhat fainter than the Glow-worm. Mr. *Brewer* farther fays, — “ Happening to come home one Night in a Sweat, and in the Dark wiping my Head with a Linnen Handkerchief, the whole Handkerchief appeared to me fhining and as it were on Fire; and whilst I viewed this feeming Miracle with Surprize, the Light was all collected in one Spot: whereupon folding the Handkerchief together, I called for a Candle, and on opening it difcovered one of thefe *Scolopendræ*, which, by being rubbed about my Head, had fspread over the whole Handkerchief I know not what kind of flaming Vapour.” — He affirms it was like the *Scolopendra* found in Gardens under Stones and Flower Pots. Vid. *Theatrum Infeft.* Cap. xv. *De Cicindela*.

I take this to be the Kind of *Scolopendra* Mr. *Willoughby* defcribes, lying rolled up amongst Earth and Dung: Its Colour a brown or whitifh yellow, the Head of a pale Chefnut, having two Antennæ; its Length half an Inch, its Tail forked: its

It seems not improper to say somewhat in this Place concerning the shining of Sea Water, since not without the Appearance of Reason, it has been supposed owing to vast Numbers of luminous Insects, of which possibly in the Waters there may be various Kinds as well as upon the Land.

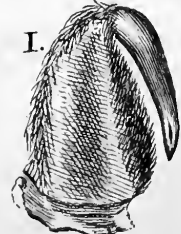
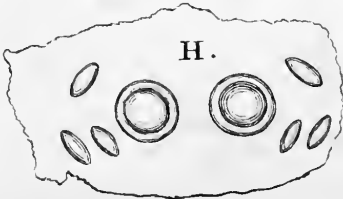
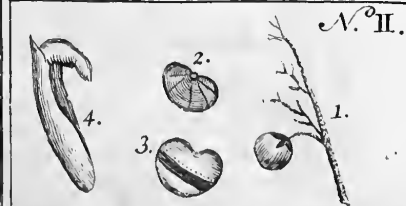
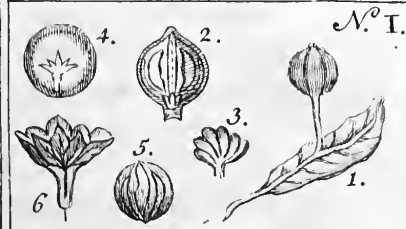
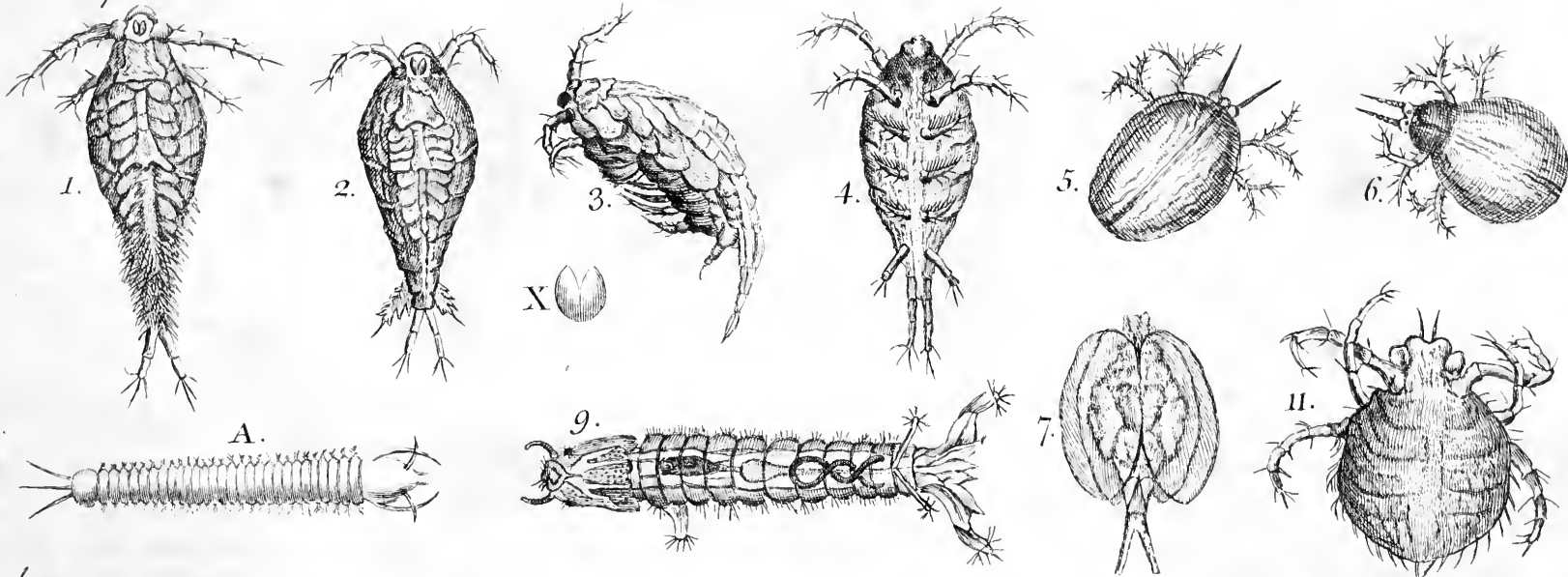
A curious Enquirer into Nature †, dwelling at *Wells*, upon the Coast of *Norfolk*, affirms, from his own Observations, that the Sparkling of Sea Water is occasioned by Insects. His Answer to a Letter wrote to him on that Subject runs thus: “ In the Glass of
 “ Sea Water I send with this are some of the
 “ Animalcules which cause the Sparkling
 “ Light in Sea Water: they may be seen by
 “ holding the Phial up against the Light,
 “ resembling very small Bladders or Air
 “ Bubbles, and are in all Places of it from
 “ Top to Bottom, but mostly towards the
 “ Top, where they assemble when the Water has stood still some Time, unless they
 “ have been killed by keeping them too
 “ long in the Phial.

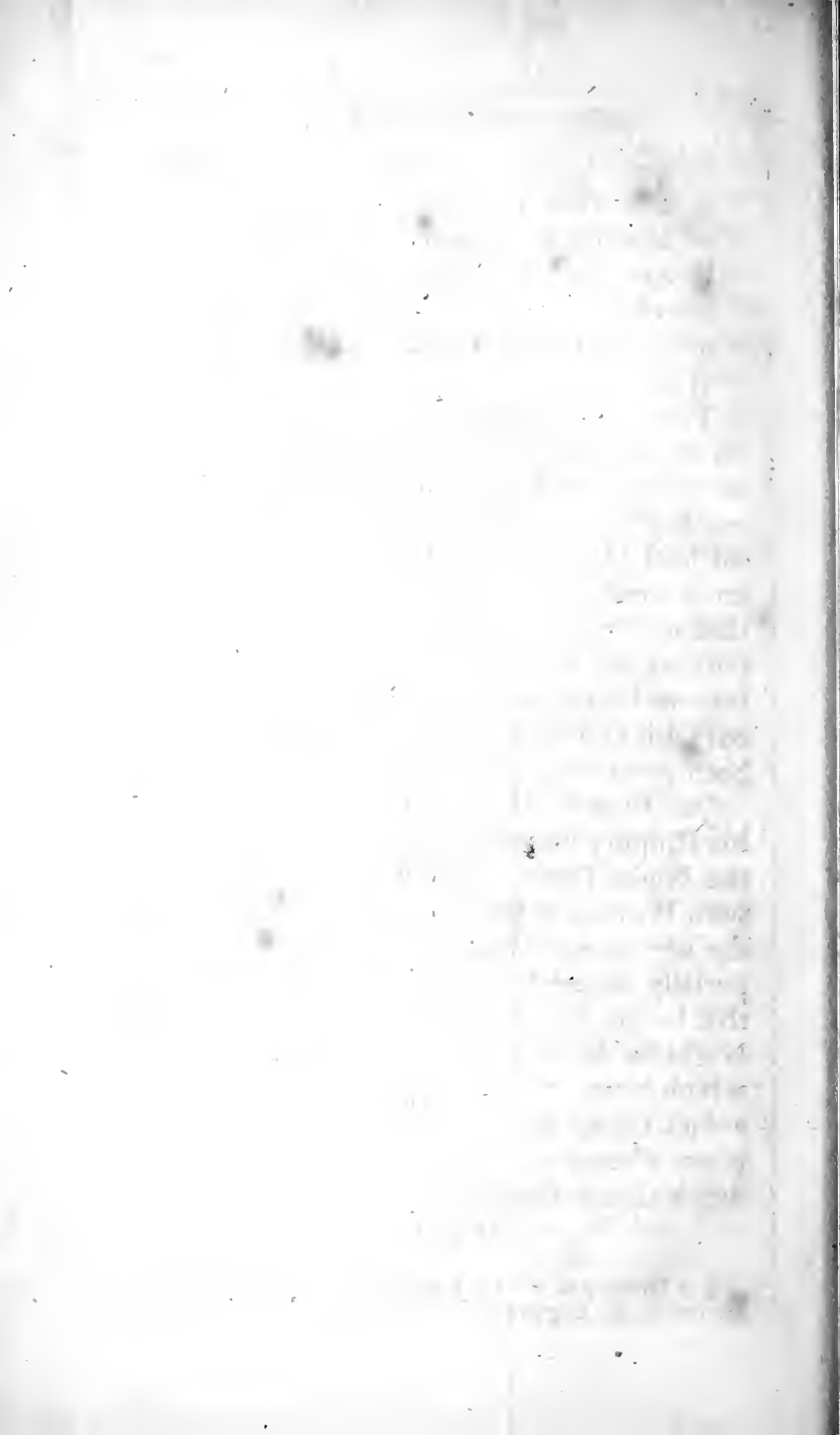
“ Placing one of these Animalcules before
 “ a good Microscope; an exceeding minute
 “ Worm

its Feet 96, (without including the Forceps at the Tail) that is 48 pair.

One Evening after Rain, says Mr. Ray, I found a small *Scolopendra* of this Sort shining like a *Glow-worm*; 'twas covered with a slimy Matter, which being wiped away, it ceased not to shine. Vid. *Ray Hist. Insectorum*, pag. 45.

† Mr. *Joseph Sparshall*.





“ Worm may be discovered, hanging with
“ its Tail fixed to an opaque Spot in a kind
“ of Bladder †, which it has certainly a
“ Power of contracting or distending, and
“ thereby of being suspended at the Surface,
“ or at any Depth it pleases in the including
“ Water.

The abovementioned Phial of Sea Water came safe, and some of the Animalcules were discovered in it, but they did not emit any Light, as my Friend says they do upon the least Motion of the Phial when the Water is newly taken up. He likewise adds, that at certain Times, if a Stone be thrown into the Sea, near the Shore, the Water will become luminous as far as the Motion reacheth: this chiefly happens when the Sea hath been greatly agitated, or after a Storm.

Jos. Vianelli, M. D. of *Chioggia* in *Italy*, in his Enquiry into the shining of Sea Water in the Night Time, (which, he says, is seen with Wonder in the Lakes of *Chioggia*, from the beginning of Summer until Autumn, especially where Sea Weeds abound,) relates, that he brought from thence, one Summer's Night, a large Vessel of this Sea Water, which being stirred about by his Hands in a dark Closet sparkled very much; but after it was filtered through a close piece of Linnen it afforded no Light at all, notwithstanding

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† A Drawing of this came with the Account, but it was too late for the Engraver.

ing all the Motion that could be given it, whilst the Linnen appeared covered with numberless lucid Particles, thereby proving the Light to be something distinct intirely from the Water.

Then examining some of the Sea Weeds, he perceived thirty at least of the like shining Particles upon every little Leaf, and shaking them over a Sheet of Paper one of the shining Bodies was thrown upon it, which being wrapped up in the Paper emitted Light quite through it. Unfolding the Paper, and viewing this luminous Body attentively, he found it far less than a small Hair, extremely delicate and tender, and of a deep yellow Colour: and by the Help of a Microscope he discovered it to be a living Animalcule, of a curious and singular Structure, and could not enough admire the Splendour of its Light. It was somewhat like a Caterpillar, and consisted of eleven Segments or Ringlets, along which near the Belly were a kind of Fins or Instruments of its several Motions. From its Head issued two Horns, and the Tail appeared twisted.

He observes, that these glittering Sea Water Insects are intirely luminous, whereas the Glow-worm emits Light only from a Part about the Tail; and, moreover, that when at rest they do not shine at all, though they send forth a prodigious Brightness as soon as their little Bodies become agitated.

Hence

Hence he accounts for the Fishermens foretelling a Tempest from an extraordinary glittering of the Sea and Lakes : these Animalcules as he supposes being disturbed and put in Motion at the approach of such a Change.

These Animalcules are found, he says, at the beginning of Summer, more plentifully amongst the Weeds than in any other Part of the Water : but they increase surprizingly in a short Time, and disperse themselves in the Waters every where †.

In *Plate xv. b, c, d*, represent a very small Insect found in some Ditch Water. *b* and *c* shew it in the Action of moving from Place to Place, which is performed by fastening the Tail-End upon the Plate of Glafs, bending the Body, extending and directing the Head downwards, then fixing the Head and drawing the Tail to it, whereby is made what may be termed one Step : and by repeating these Steps its Progression was pretty nimble, and much resembled that of the Species of Catterpillars called *Loopers*. Its Posture when at rest after being tired with Motion, or just before it began to set forwards, is seen at *d*.

I could not by the strictest Observation discover any suitable Apparatus about the

D d 3

Head,

† A large Account of this may be seen, translated from the *Italian*, in the *Universal Magazine*, for *December*, 1751.

Head, or else from its Appearance should have judged this little Creature to be a Species of the *Wheel-Animal*, which it imitates in other Respects very nearly.

C H A P. XXX.

The LOUSE of the BAT.

MOST living Creatures are supposed to have their Lice, Fleas, or little Tormentors, of Kinds and Forms peculiar to themselves : such have been found in great Numbers on many Sorts of Beasts, Birds and Fishes, at some particular Seasons; Flies, Bees, Earwigs, Spiders and many other Insects are sometimes in like manner pestered with them : nay, even the nimble Flea which teazes us and sucks our Blood, is not free itself from Blood-suckers, which harbour very conveniently under the Scales of its Neck, and about its Legs and Belly, clinging too fast to be shaken off. We are obliged to Seignior *Redi* for the Figures of the *Pediculi* peculiar to several Kinds of Beasts and Birds ; but I suppose he had no Opportunity of observing that of the Bat, which I am now going to describe.

The little Animal which the Reader is directed to take notice of, at the Letters E, F, G, *Plate XV.* was found adhering firmly

to the filmy Wing of a Bat then but newly dead, and is undoubtedly the Vermin of that Creature: many others were probably concealed under its short thick Hair, but being intent on examining this with the Microscope and making Drawings of it, I omitted searching after more.

Its Body is nearly circular, and about the 30th Part of an Inch in Diameter. It is furnished with eight Legs, each having six Joints: the last Joint terminates in a transparent Tuft or Ball, like those at the Feet of some Flies, but much larger and more spreading in proportion to its Size, whereby it is enabled to fasten itself strongly to whatever it stands upon. Two small Antennæ or Feelers are placed at the Anterior and a small Process or Tail at the Posterior Part of this Animal. A peristaltic Motion, or rather a Contraction and Dilatation are alternately carried on through the Intestines, which appear more opaque than the Parts about them, and somewhat in the Shape of the Letter X.

This Animal is shewn in its natural walking Posture with its Back uppermost at E, and again at F with its Back downwards and its Belly next the Eye. It lived more than twenty-four Hours between two Talcs, and died nearly in the Posture shewn at E, F, as it still continues in the Slider now before me.

As the Bat is extremely swift in its Flights and Returns, it was requisite the Vermin living on it should have some extraordinary Power of preventing its being thrown off; and accordingly this little Insect is not only provided with larger Tufts or Balls than usual at the Extremities of its Feet, but has also another very remarkable and uncommon Means of preserving its Situation; for on any sudden Emergency, instead of walking on its eight Legs, as it usually does, it can, in an Instant, turn four, six, or all of them occasionally, so far backwards as to catch hold of any thing, and walk on them with its Back as easily as with its Belly downwards; and I often observed it with four Legs in their right Position and the other four erected over its Back and ready to lay hold as at G. Hereby it is enabled to shift its Posture instantly, yet still maintain its Ground notwithstanding the swiftest Motions, as I had the Pleasure of experiencing in several Attempts to jerk it off from a Quill, from my Finger, and from other Things it fixed itself upon, which all my Endeavours could not effect.

C H A P. XXXI.

Observations on a large SPIDER.

HAVING received a Spider from the Island of *Nevis*, of a larger Size than I had ever seen, I pleased myself with the Hope of obtaining thereby a better Knowledge of Spiders in general, than I possibly could by the nicest Examination of the smaller Kinds.

On measuring it pretty exactly, the Length of its Body and Tail was found to be $2\frac{1}{8}$ Inches: the Breadth of the Body and the widest Part of the Tail very near an Inch. It had ten Legs, of which the foremost two were shorter than the rest, but the other eight were each three Inches long at least, and in their thickest Parts a Quarter of an Inch Diameter. Such were the Dimensions when dried, and consequently much shrunk and lessened: when alive it probably appeared nearly twice as big. The whole Body and Limbs were thickly covered with long Hair. The Body was of a brown Colour; the Tail was also brown, except one longitudinal indented Stripe of white, which passed along its Middle from where it joyns the Body to the Arms. The Termination of each Leg was a curious Tuft of long soft Hairs, under which lay concealed a Couple of exceeding sharp

sharp hooked Claws, which must be greatly serviceable in clambering, to cling to any thing, or to seize the Prey.

The Body was crustaceous, having a Shell as hard as that of a small Crab, the Tail Part was soft and downy ; on the Back both of the Body and Tail the Hairs were shorter than elsewhere. The two Fangs were strong, black, hard and horny, terminating and being Parts of two short thick Limbs to which they were articulated, projecting from the Body directly before the Mouth. One of these Fangs magnified about three times is shewn at Letter I. They were not placed horizontally like a Pair of Forceps, fitted to catch and hold Things by bringing their Points to meet, as in most of our English Spiders, but they lay Side by Side with their Points bending downwards, and in Readiness to strike either singly or together, after the Manner of the *Tarantula*. These deadly Weapons of the Spider I was very industrious to examine, and by my Glasses could discern very distinctly a minute Opening or Slit near the Extremity of each Fang just in the Front thereof, through which one can hardly doubt a poisonous Juice was ready (when the Creature was alive) to be ejected into the Wounds it made. This Aperture is described by Mr. *Leeuwenhoek*, in the 272d Number

Number of the *Phil. Transf.* pag. 868 † : but Dr. *Mead* having examined the Weapons of several Spiders, and particularly of one very large, without finding it, was inclinable to believe, when he published his curious Account of Poysons, that Mr. *Leeuwenhoek* had been mistaken, and that the Fangs were capable of inflicting a Wound only ; into which a poisonous Liquor was instilled afterwards by a short white Proboscis thrust out of the Spider's Mouth *. Having also never seen it myself at the Time I wrote my *Treatise on the Microscope*, I was then of the same Opinion. But as soon as I made the above Discovery, which was in *April* 1746, I shewed the Fangs I have been describing to Dr. *Mead*, who was much pleased with a Sight of this Aperture, and with his usual Candor gave it as his Opinion, that as amongst Serpents some Kinds only are poisonous, and have Teeth that are perforated for the Emission of their Poyson, viz. the *Rattle Snake*, the *Viper*, &c. whereas the Generality are harmless and have no hollow Teeth ; so likewise some Kinds only of Spiders are poisonous, or have any Perforation in their Fangs : but such whose Fangs are perforated may be supposed uncommonly dangerous.

It

† See also *Arc. Natur.* Tom. IV. Pars II. pag. 39.

* *Vid. Mechanical Account of Poysons*, third Edit. pag. 88.

It would not be strictly honest to pass over this Subject, without declaring in Justice to the Memory of Mr. *Leeuwenhoek*, that notwithstanding I have sometimes thought him mistaken in his Descriptions of Things examined by the Microscope, it has seldom happened, but that afterwards I have found such his Descriptions true, and that the Objects I had formerly judged from were not exactly of the same Sort, or in the same Perfection as his: And this I hope will make others cautious, not immediately to determine in Matters of this Nature from a single and perhaps a slight Examination; which I believe too often has been the Case.

Having satisfied myself concerning the Fangs of this Spider, I proceeded to an Examination of its Eyes, which I found to be eight, situated on the Summit of the anterior Part of the Body; for I think a Spider cannot properly be said to have any Head. I cut out a Portion of the Shell or Crust in which the Eyes were placed, that I might bring them with more convenience to my Glasses. And I soon saw that the two Middle Eyes were much larger and more remarkable than the rest, and seemed exactly round, and that the three small ones on either Side were oval. The Disposition, proportionable Size and Appearance of them all together may be seen at H.

After

After clearing away from the inner Part of the Shell the Blood Vessels and other Integuments of the Retina, or perhaps the Brain, the two larger Eyes (which were each as big as a middling Pin's Head) appeared to be transparent spherical Bodies of an Amber Colour. Part of each Sphere projected externally beyond its Socket, but the largest Part was sunk internally within it, and there was round each a circular transparent Membrane by which it seemed to be fastened †.

The Figure and Transparency of these Eyes raised in me a Desire to see with the Eye of a Spider; and therefore cutting them out very carefully, (for in their natural Situation they could not answer my Purpose) I took the Pains to set each of them in a Pin-

† *Spiders* Eyes are not pearled or composed of smaller Eyes like those of *Flies*, *Beetles*, and most Kinds of Insects: they resemble more the Eyes of Quadrupeds, but are not moveable, which is probably the Reason why Providence has furnished the Spider with more Eyes than Insects that have Eyes pearled, or Animals whose Eyes can turn: for as Safety requires that Creatures should be able to discover Danger, or even their Food, on whatever Side it lyes, some have pearled Eyes, or more properly Clusters of Eyes, which (tho' not moveable) are directed every Way: the Eyes of others are as it were multiplied by Motion; but Eyes like those of the *Spider*, and immoveable, would be unable to answer these Purposes, unless there were more than two.

Indeed the *Shepherd Spider* has two Eyes and no more: but then its Legs are so very long, its Body so small, and those Eyes are placed in the Middle of its Back on such an Eminence, and in such a Direction, that they take in nearly a whole Circle. A fuller Account of this Spider and Figure of its Eyes may be seen in Dr. Hook's *Micrographia*.

Pin-Hole made through a Piece of Card, whereby I could employ them to view Objects with. Their magnifying Power was very great, and had they been taken from a Spider newly dead, I have Reason to believe they would have given me much Pleasure : but having been drying for some Years, they had contracted a Cloudiness that prevented Objects being seen through them with any tolerable Distinctness. I am not however without Hopes of bringing this Experiment some Time or other to succeed, even with our *English* Spiders.

The wounding Instruments of most Animals, whose Bite or Sting is poisonous, resemble in their Contrivance the Fangs of the Spider just now described ; as will be easily comprehended by viewing the Tooth of a Viper, pictured in this same Plate at L ; wherein a similar Opening is shewn, through which, on biting, a poisonous Juice is thrown into the Wound ; and also by the Fang of an Indian *Scolopendra* or *Millepes*, near whose Point there appears a like Opening, serving to the same Purpose, at the End of a long Slit or Fissure, as may be seen at K. The Weapon with which the *Scorpion* strikes has likewise such an Aperture.

C H A P. XXXII.

Miscellaneous Observations.

HAVING described all the Figures given in the preceding Plates, I shall add a few Observations in a miscellaneous Manner.

In the Waters of some Ditches there is found a very small Sort of Leech, of a pale brown Colour, whose Length is about half an Inch when extended fully. Several Months in the Year its young ones are carried about with it where-ever it goes, sticking fast underneath its Belly. Their Number is usually 8, 10, or 12 ; and if separated from the Parent, even to some Distance, they immediately replace themselves, and that so regularly they might easily be mistaken for Legs, whilst they are stretching themselves out beyond its Body, with their Heads waving to and fro, which is their constant Posture when the Parent Animal is in Motion. This Subject deserves farther Examination.

Curious Cases are made by a small Worm or Maggot, with admirable Dexterity, of the Stalks of *Duckweed*, which the little Creature bites asunder with its Pincers, places with great Order and Exactness like the Threads of a Linnen Cloth, and glews together. 'Tis diverting to see the brisk Inhabitant come a little Way out of its Door, either for Food or Pleasure, and immediately

ately on the Apprehension of Danger pop in again, leaving nothing to be seen but a few green Stalks.

In the Spring of the Year I have several times observed great Numbers of little Cafes, on a Row of Pales by the Side of the New River at *Enfield*, made in the prettiest manner imaginable of the green microscopic Mofs growing on the same Pales. They were open at both Ends, and about a quarter of an Inch in Length : each contained a little black Maggot, that put out its Head or Tail occasionally, and became at last a small black Fly.

Amongst the *Eels in Vinegar* one shall sometimes find accidentally a pretty and surprizing Phænomenon, *i e.* a Chain or Series of minute Globules seemingly strung together like a Necklace of Beads. These are nothing more than a Row of Air Bubbles lying one behind another in the dead Body of one of the *Anguillæ* ; which Body from its great Transparency is not visible, unless by the greatest Magnifier.

My good Friend Dr. *Miles* happening to take Notice of a bright green *Mouldiness* on the Bark of some Fire-wood : and, by a Lens of an Inch Focus, finding it to be Numbers of minute *Fungi* of a regular Appearance, he employed a large Magnifier, through which their spherical Heads seemed as if they were nothing else but Globules of Seeds. He
observed

observed, at the same time, several Seeds adhering to the transparent Foot-stalks which supported the Heads, and many scattered on the *Glass Plate* whereon the Substance was placed for view; whereby he had an Opportunity of seeing many distinct Seeds, nearly of an oval Form, but several times larger than the Seeds of *common Mushrooms*, even when seen with the second Magnifier, and the latter with the first.—He says, he has often viewed the Heads of a small Kind of coriaceous Fungus of about $\frac{1}{8}$ Inch Diameter, and always found the Seeds on their Gills much larger than those of any other Mushroom he had examined, tho' rather less than those this unregarded Plant produces.

He sent with this Account a Piece of Wood with the *Mouldiness* thereon, and also some of it on a Slip of Glass: both which I examined carefully to determine the Bigness of the Heads and their Seeds: and viewing the Spherical Heads of the middle Size, (some being larger and others smaller) I found, (according to my *Micrometer*,) that 3 of them took up the Side of a Square, 70 of which Squares make an Inch in Length: consequently thrice 70, or 210 of these *Fungi*, make a Line of one Inch: or, in other Words, the Diameter of these *fungous Bodies* is, at a Medium, the 210th Part of an Inch.

The Seeds are oval; and I find, by the same *Micrometer*, that 10 of them laid by one another the shortest Way of their Diameter, or 8 of them the longest Way, fill up the Side of a Square, 270 of which Squares make an Inch in length.---Taking therefore 9 as the Medium, 270 times 9, or 2430 of these Seeds will be required to make a Line of an Inch in length; or in other Words, each Seed is the 2430th Part of an Inch in Diameter.---And according to these Calculations 44100 of the Spherical Heads, or 5,904,900 of their Seeds, may lye by one another in the Surface of an Inch square.

Yet minute as the Seeds of this little *Fungus* are, the Doctor observes very justly, that they are bigger than those of some others of the same Genus which exceed it Thousands of Times in Bulk. For the Seeds of a very large *edible Mushroom* being examined, by a Glass magnifying 320 times in Diameter, and their Figure being elliptical, 7 of their longest and 8 of their shortest Diameters were found equal to the length of a Line known to be the 500th Part of an Inch. So that the longest Diameter of each Seed was the 3500th, and the shortest the 4000th Part of an Inch in length, and 14,000,000 of such Seeds would be required to cover a Surface of one Inch square.* The

* All the Species of *Funzi* were formerly supposed to bear no Seeds: Ray says of them, *nulla nec Semine nec Flore*; but good Glasses now convince us of their producing Seeds in vast abundance, growing commonly between the Gills.

The *proportionable* Size of Fruits and Seeds to the Trees and Plants that bear them, comes under no Rules that correspond with our Conceptions. The *Beech* and *Ash* are produced from Seeds smaller than the Garden *Bean*. The *Oak* has for its Fruit only a small Acorn; whereas the *Pumpkin*, whose Weight sometimes exceeds 100lb is the Production of a feeble creeping Plant, unable to support itself, much less its enormous Fruit. The *Vanilla*, (climbing to the Height of several Feet) produces in long Pods Seeds so small, their Diameter is not more than the 100th Part of an Inch. Then supposing the Cavity of its Pod equal to a cylindrical Tube of $\frac{1}{10}$ Inch Diameter, and its length to be six Inches, (which Dimensions are taken with great Moderation) the Number of Seeds in one single Pod will be more than 47000. — These Seeds ground with Chocolate give it a rich Perfume.

I could add many more Observations, which perhaps some of my Readers might be pleased with, but finding this Work has grown under my Hands, much beyond the Size I intended, I shall hasten to conclude this part with recommending the *Study of Nature* to all who have Leisure and Opportunity for it, as affording the most reasonable Pleasure the Mind of Man is capable of enjoying.

The World around us is the mighty Volume, wherein the Great Creator with his

own Finger has described himself. Human Writings consist of *Lines* and *Figures* intended to denote the *Sounds* or *Words* of Language; which being at first arbitrarily apply'd, were afterwards by common Consent and Custom allowed to represent certain *Ideas*, tho' without any Resemblance to them. And as very different *Sounds* and *Marks* have been employed, by Nations Strangers to each other, to express and denote the same *Objects of the Senses*, or *Conceptions of the Mind*, hence arose different *Languages* and *Characters*, which must therefore be unintelligible to all who have not previously been instructed in their Signification and Use; nor can be attained without a great deal of *Pains* and *Attention*. But the *Book of Nature* is written in an *universal* and *real Character*, which every Man may read in his own Language; for it consists not of *Words* but *Things*, which picture out the Perfections of the DEITY. The starry Firmament every where expanded, with its numberless Systems of Suns and their surrounding Planets, the Regularity, Harmony, Order and Constancy of their Motions, declare the Immensity and Magnificence, the Power and Wisdom of their Creator. Thunder, Lightening, Tempests, Hurricanes, Earthquakes, and Volcano's, shew the Terror and Destruction of his Wrath. Seasonable Rains, Sunshine, and plenteous Harvests, denote his Bounty and Goodness, and his Regard for the Happiness

Happiness of all his Creatures ; and demonstrate how, when his Hand is open, he fills all things living with Plenteousness. The constant Succession of Generations in Plants and Animals, implies the Eternity of their first Cause. Life every where subsisting in Millions of different Forms, shews the boundless Diffusion of his Animating Power ; and Death the infinite Disproportion between him and every living Thing.-Even the Actions of Animals are an *eloquent* and *pathetic Language* ; those that want the Help of Man, have a thousand engaging Ways, which like the Voice of God speaking to his Heart, command him to preserve and cherish them ; whilst the Looks and Motions of such as would do him harm, strike him with Terror, and warn him to fly from or arm himself against them. In short, every part of Nature directs us to Nature's GOD ; for according to *Lucan* in that fine Speech he makes for *Cato*,

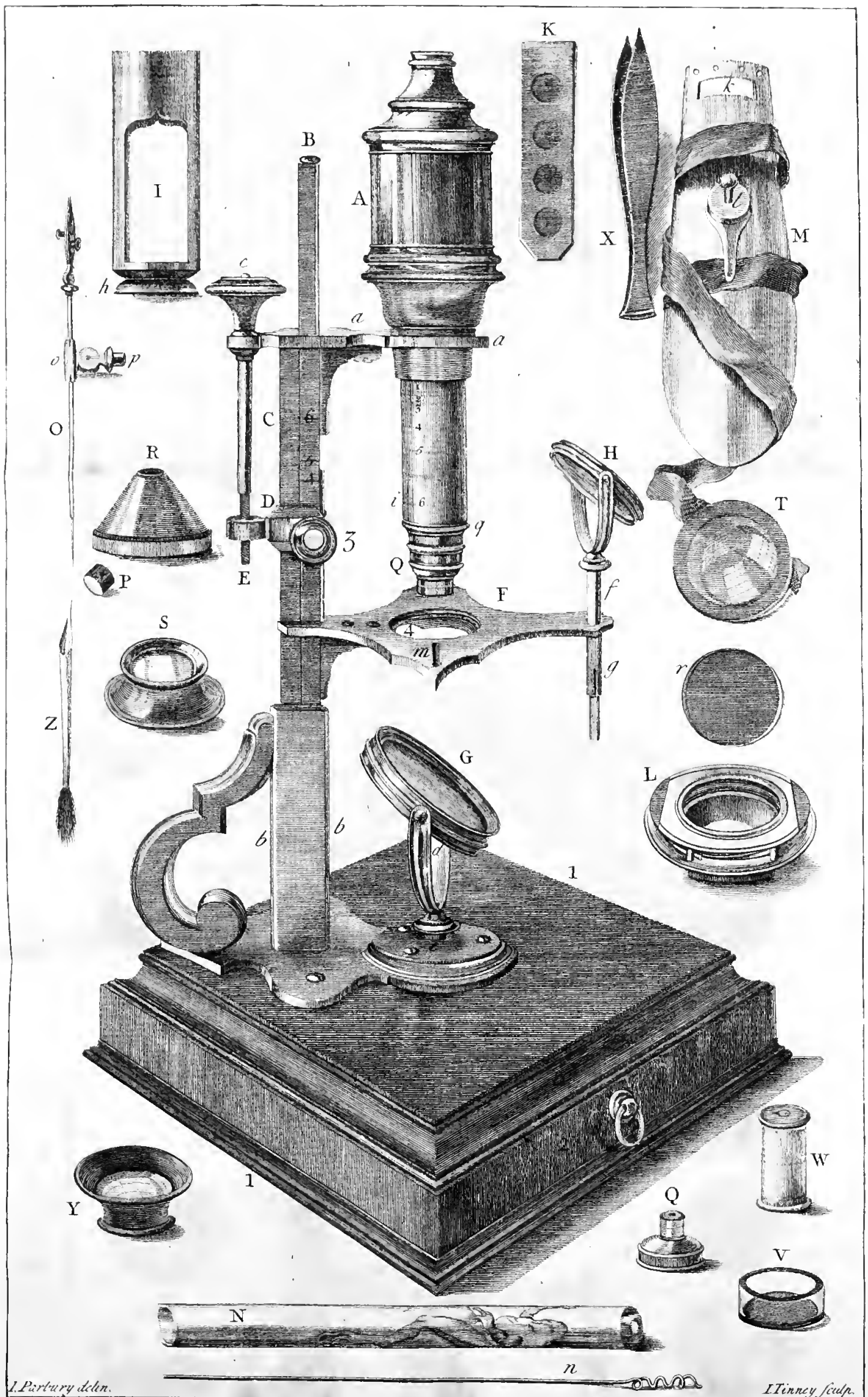
JUPITER *est, quodcunque vises, quocunque moveris* ;
which I shall translate with great Liberty,
and by the Way of Paraphrase,

Range where you please, through Water,
Earth and Air,
GOD is in every Thing, and every where.

*Some Account of a new constructed Microscope,
used in the foregoing Experiments.*

THE cumbersome and inconvenient **DOUBLE MICROSCOPES** of *Dr. Hook* and *Mr. Marshal*, were many Years ago reduced to a manageable Size, improved in their Structure, supplied with an easy Way of enlightening Objects by a Speculum underneath *, and in many other Respects rendered agreeable to the *Curious*, by *Mr. Culpepper*, and *Mr. Scarlet*. Some farther Alterations were however wanted to make this Instrument of more general Use, as I fully experienced in the Year 1743, when examining daily the Configurations of Saline Substances, the Legs were continual Impediments to my turning about the Slips of Glass; and indeed I had found them frequently so on other Occasions. Pulling the Body of the Instrument up and down was likewise subject to Jerks, which caused a Difficulty in fixing it exactly at the Focus: there was also no good Contrivance for viewing opaque Objects. Complaining of these Inconveniences, *Mr. Cuff*, the Optician, applied his Thoughts to fashion a Microscope in another Manner, leaving the Stage intirely free and open by taking away the Legs, applying a
fine

* See *Microscope made easy*, Plate III. pag. 16.



A new constructed Double Microscope, as made & sold by
 the Inventor **JOHN CUFF** in Fleet street London.
 Published according to Act of Parliament September 20th 1744.

fine threaded Screw to regulate and adjust its Motions; and adding a concave Speculum for Objects that are opake.

The foregoing Examinations having been all made by an Instrument thus improved, I shall give a Plate and Description of it, (as an Addition to my former Book on the Microscope) by the Name of Mr. *Cuff's new-constructed Double Microscope.*

All Parts of this Instrument are Brass. --- The Body A, being firmly supported in a broad circular Collar at the End of the Arm *a a*, which projects from the Top of the Pillar C, may be taken out or put in at Pleasure.

A square Box *b b*, screwed down to the wooden Pedestal I I supports the whole Machine, by the Assistance of the long flat-square Pillar B, which is fixt within the said Box.

The moveable Pillar C, which is shorter than the Pillar B tho' of the same Shape, by sliding up or down against the broad flat Side of the said Pillar, raises or lowers the Body of the Microscope as occasion may require. --- Both Pillars stand in the Box *b b*.

The square Collar D holds the two Pillars B and C together, and slides up or down upon them, carrying with it the Body of the Microscope. --- The Screw-Button 3 is intended to fix the Pillar C, when the upper Edge of the Collar D being set at the same

Number as that of the Magnifier employed, its focal Distance is brought nearly right.

When the Pillar C is fastened, the Microscope (by the fine-threaded adjusting Screw E) may be moved so gently up or down, without Jerks, or Slips, that the true Focus may be found with great Readiness and Exactness.

The horizontal Plate or Stage F, having in the Middle thereof a circular Hole *a*, directly over which the Body of the Microscope is suspended, is exceedingly convenient to place Objects on for Observation, being freed intirely from the Legs which incumber other Double Microscopes.

The concave Looking Glass G, turning on two small Screws in the Arch *d* (at the Bottom of which a Pin goes down into the Hole *e* in the Pedestal) reflects the Light of a Candle or the Sky directly upwards on the Object, by moving the Looking Glass horizontally or vertically.

A double convex Lens H, turns on two Screws, for transmitting Light to assist in illuminating opaque Objects, when the long round Wire *f* is placed in the Spring-Tube *g*, at the Corner of the Stage F.

I-- is a hollow Cylinder whose sides are open, and at whose End a concave Silver Speculum *b*, having a round Hole in the Midst thereof, is screwed. This Cylinder slips over the Snout *i* of the Microscope, and
when

when set to the Figure there marked, and correspondent to the Number of the Magnifier made use of, the Silver Speculum reflects Light on the opaque Object to be examined; which Object must either be held in the Spring-Tongs at one End of the Wire O, placed in the Slit *m* on the Stage F; or be put on the Ivory Block P, stuck on the pointed End of the said Wire. The third or fourth Magnifiers are fittest to be used with the Silver Speculum.

K. L. M. N. Q. Q. R. S. T. V. W. X. Y. Z. are different Parts of the Apparatus which I think needless to describe, as all who are acquainted with *Microscopes* will know them at first Sight, and others may inform themselves either in my former Treatise on these Subjects, or in the Book which Mr. *Cuff* gives to those who buy this Microscope of him.

In the Year 1747 a Micrometer for this Instrument was also contrived by Mr. *Cuff*, being a Lattice of fine Wires, placed (when made use of) in the Focus of the Eye-Glass, by unscrewing the Body of the Instrument. As the Readiness wherewith the real Size of Objects may be calculated by this Micrometer must render it valuable to the Curious, there needs no Apology for laying some Account of it before them, drawn up and given to me by my much honoured Friend *Martin Folkes*, Esq; President of the *Royal Society*,

Society, and first President, (under the Royal Charter,) of the *Society of Antiquaries of London* †.

Remarks on a Micrometer to be applied to Double compound Microscopes. By MARTIN FOLKES, Esq; P.R.S.

THIS Micrometer only consists of a Lattice of fine Silver Wire distant from each other one fiftieth part of an Inch, intersecting at right Angles, and so placed in the Focus of the Eye Glass, as to divide the whole visible Area of the Microscope into Squares, whose Sides are each the $\frac{1}{50}$ th of an Inch.

Now as the Image of any Object to be examined is formed in this Place, it is plain that by this Lattice Work such Image may readily be measured, either by comparing its Length or Breadth with the Distance of the

† This Gentleman, whose amiable Character for Ability in Science and Goodness of Heart is known and respected by all the World, being unhappily disabled by a paralytic Disorder from attending the Meetings of the *Royal Society*, where for eleven Years he had presided with great Honour, thought proper on the last annual Day of Election, viz. *November 30th 1752*, to decline being again elected President. Wherefore the Gentlemen of the said Society, after returning their most grateful Acknowledgments to Mr. *Folkes* for his many and useful Services, elected unanimously the Right Honourable the *Earl of Macclesfield* to be their PRESIDENT in his Stead.

the Wires : or by comparing its whole visible Superficies with one or more of the little Squares formed by the Interfection of the same Wires.

And the true Size of the magnified Image being thus known, the true Magnitude of the Object itself will be known also, if the magnifying Power of the Object Glass is but given : and this will easily be found in the following practical Manner.

Let a minute Object of a known Size, be carefully viewed in the Microscope : as for example ; Part of a fine diagonal Scale divided into the Millefimals of an Inch ; and let it be examined how many of those Millefimals answer to the Distance of two of the Wires abovementioned, remembering to estimate that Distance from the Outside of one of the Wires to the Inside of the other. For as 20 are to that Number of Millefimals just found, so is the Length or Breadth of any Image measured by the Micrometer to the Length or Breadth of the Object itself : or as 400 are to the Square of the same Number of Millefimals, so is the magnified Superficies of any Image, to the true similar Superficies of the Object.

And again, as that Number of Millefimals of an Inch just found is to 20, so is Unity to a Number expressing how many times the Length or Breadth of any Image estimated by the Micrometer, is greater than the true
Length

Length or Breadth of the Object itself: and this last Number I call the magnifying Power of the Object Glass.

This Trial is to be made with Care once for all, for every different Object Glass to be used with the Micrometer: and their different resulting magnifying Powers, once registered in a Table, will be ready upon all Occasions. For thus the Length or Breadth of any Image estimated by the Micrometer, will when divided by the magnifying Power of the Object Glass, express the true Length or Breadth of the Object itself: or the Superficies of any Image estimated by the Micrometer, in square Millefimals of an Inch, will in like Manner express the true similar Superficies of the Object itself; if it is divided by the Square of the magnifying Power of the Object Glass used. And for this purpose it may be of use to set down in another Column of the Table, the respective Squares of the Numbers expressing the magnifying Powers of the several different Object Glasses.

As some Difficulty may be found, in applying the diagonal Scale abovementioned to the larger Magnifiers: chiefly thro' want of Light when the Object is to be brought very near to the Glass; that Defect may be supplied by the use of some minute natural Object, whose true Size has already been carefully determined by one of the lesser Magnifiers,

fiers, and whose Image is again viewed with one of the greater : for as the Number of Millefimals of an Inch contained in its true Length or Breadth, are to those now found in the Length or Breadth of its Image, so will Unity be to the magnifying Power of the Object Glass now made use of, &c.

I should now farther take Notice, that the Numbers here called the magnifying Powers of the several Object Glasses, do not express the whole magnifying Power of the Microscope. For the Image formed in the Focus of the Eye Glass is again magnified to the Eye, by the Operation of the Eye Glass itself. And the Focus of this Eye Glass being, in the Double compound Microscope made by Mr. Cuff, and which he calls (tho' somewhat improperly) his new double *reflecting* Microscope, at the Distance of one Inch and a quarter nearly ; the Eye, placed on the other Side, views the Image of any Object formed in that Focus, under an Angle about seven times as great as that under which it would see it with Distinctness if naked, and at the Distance of somewhat less than nine Inches. We may therefore then consider all Images viewed with this Microscope as magnified seven times in Length or Breadth, or 49 times in Superficies by the Intervention of the Eye Glass : and we may consequently express the whole magnifying Powers of the Microscope, if we respectively multiply the
Numbers

Numbers already placed in two Columns of the Table, by 7 and 49.

I would just observe, that some Double Microscopes have a Drawer between the Glasses, and by means of which they magnify differently with the same Glas: in these Microscopes therefore one Position of the Drawer should be pitch'd upon as the most convenient, and the same should constantly be used whenever any Magnitude is to be determined by the Micrometer applyed to the same.

The Lattice abovementioned, whose Wires are only distant a fiftieth of an Inch, may upon some Occasions be found inconvenient in viewing of Objects. But it may very easily be taken out and put in occasionally, or have its place supplied by another whose Wires may be the 20th, or the 10th of an Inch asunder; and this last especially will give no hindrance to common Observations, and will besides be very useful to such as would draw with some Exactness any of the Objects they examine with their Microscope.

I am told that Silver Wire may be had to make these Lattices of, whose Diameter is rather less than the seven hundredth part of an Inch."

The mention Mr. *Folkes* makes of a Lattice whose Divisions are $\frac{1}{10}$ of an Inch, was owing to his having experienced the Utility of such an one in my Microscope, made by myself of human Hairs, and fastened exactly
in

in the Focus of the Eye Glass, whose Distance being $1\frac{1}{4}$ Inch, or $\frac{1}{6}$ ^{ths} of nine Inches, (the Standard of Sight he computes by *,) the Diameter of an Object seen through that Glass is magnified 7 times, and the Side of each Square whose real Length is $\frac{1}{10}$, appears (magnified through the said Glass) to be $\frac{7}{10}$ ^{ths} of an Inch.

Employing different Object Glasses or Magnifiers in viewing Objects, makes no Difference in the Lattice or Micrometer, whose Squares are magnified by the Eye Glass only, and always appear of the same Diameter, that is, $\frac{7}{10}$ ^{ths} of an Inch. But the Object being more or less magnified according to the Power of the Object Glass, the Image thereof thrown upon the Lattice extends over more or fewer of its Squares: whence the magnifying Power of all the Glasses belonging to my Microscope, and the real Size of Objects examined by them, are shewn in the following Table.

A Table

* The usual Standard of Sight is 8 Inches, but as Mr. Folkes has thought proper to make it almost 9 Inches, all these Calculations are conformable thereto.]

A Table of the *magnifying Powers* of the Glasses belonging to my own *Double compound Microscope*, together with the Measure of a single Square of the *Micrometer* compos'd of tenths of an Inch, when any one of the Glasses is employ'd; according to the foregoing Method of Calculation.

When the Object Glas No.	is made use of	An Object is magnified in Diameter	320 189 161 48 49 28 17½	Magnified in Superficies	122500 35621 25921 7056 2401 754 306¼	Times	The Side of each Square in the Hair	Micrometer measures the	Part of a magnified Inch in Length	The Area of each Square in the Hair	Micrometer measures the	Part of a magnified Inch in Length	The Area of each Square in the Hair	Micrometer measures the	Part of a magnified Inch in Length
0	1						500 th		270	250000 th		250000 th			
1	2						120		230	72900		72900			
2	3						70		120	52900		52900			
3	4						40		70	14400		14400			
4	5						25		40	4900		4900			
5									25	1600		1600			
										625		625			

Remarks on a *Micrometer*, &c.

The Magnifiers are distinguished in the first Column by the N^o 1. 2. 3. &c.
 The second Column shews how many times each Glas magnifies the Diameter of any Object.
 The third Column shews how many times each Glas magnifies the Superficies of any Object.
 The fourth Column determines the true Length of any Object, by shewing what Part of the Length of an Inch such Object really is, when viewed by either of the Glasses, it appears the Length of one Square of the Micrometer.
 The fifth Column determines the true Size of any Object, by shewing what Part of a square Inch such Object really is, when, viewed by either of the Glasses, it fills up the Area of one Square of the Micrometer.

* This Glas, whose magnifying Power is extraordinary, was made particularly for me.

For Example. — An Object, or Part of an Object, whose Diameter when viewed through the Magnifier N^o 1. appears the exact Length of one Square of the Hair Micrometer, is really no more than the 270th Part of an Inch in Length.

And if, when viewed through the same Glass, it appears to fill up the whole Space of one of the said Squares, its real Area is no more than the 72900th Part of a Square Inch, &c.

In order to render this Instrument still more useful, Squares may be drawn on Paper (with very black Lines) correspondent to those of the Micrometer magnified by the EyeGlass, *viz.* $\frac{1}{270}$ ths of an Inch diameter; by the Means whereof, (if placed under so thin a Paper as they can plainly be seen through,) an Object may be drawn exactly of the Size it appears when magnified by any Glass whatever. — Nine Squares so drawn are shewn *Plate XVII. fig. 6.*

In the same Plate, *fig. 4.* shews a Micrometer whose Divisions are the Fiftieths, and *fig. 5.* another whose Divisions are the Tenths of an Inch: And this last may remain in the Body of the Microscope, without being any Hindrance, whatever Glass is used.

'Twere well if the Workmen ground their Glasses so exactly to a Standard, that the same Table might serve for the Micrometer to every Set of them; but as that is

not the Case, a particular Table must be made for every Set of Glasses.

Of Mr. LEEUWENHOEK's *Microscopes*.

THOUGH Mr. *Leeuwenboek's* Microscopes are much talked of, very few People are acquainted with their Structure and Apparatus, no Figure of them that I remember having ever been made publick: 'tis therefore hoped the Curious will be pleased to see a Drawing of them, taken with great Exactness from those in the Repository of the *Royal Society*, which are all alike in Form, and differ very little in Size from this Drawing, or from one another. *

The two Sides of one of these Microscopes are shewn *Plate XVII. fig. 7* and *8*. The Eye must be applied to the Side *fig. 7*. --- The flat Part *A* is composed of two thin Silver Plates fastened together by little Rivets *b b b b b b*. Between these Plates a very small double-convex Glass is let into a Socket, and

* An accurate Description of the 26 Microscopes, and Objects belonging to them, contained in a small Cabinet which Mr. *Leeuwenboek* at his Decease bequeathed to the *Royal Society*, was presented many Years ago to that Society by *Martin Folkes*, Esq; and may be seen N^o 380 of the *Philosophical Transactions*. And a farther Account, setting forth the magnifying Powers, and other Particulars concerning the same Microscopes, (which were three Months under my Examination for that Purpose) was presented by me to the *Royal Society* in the Year 1740, and published *Phil. Trans.* N 458. But neither of these Accounts has any Drawing of the Microscopes.

and a Hole is drilled in each Plate for the Eye to look through at *c*. A Limb of Silver *d* is fastened to the Plates on this Side by a Screw *e* which goes through them both. Another Part of this Limb, joined to it at right Angles, passes under the Plates, and comes out on the other Side; (*Vid. fig. 8*) at *f*: through this runs, directly upwards, a long fine-threaded Screw *g*, which turns in and raises or lowers the Stage *b*, whereon a coarse rugged Pin *i* for the Object to be fastened to, is turned about by a little Handle *k*; and this Stage with the Pin upon it is removed farther from the magnifying Lens, or admitted nearer to it, by a little Screw *l*, that passing through the Stage horizontally, and bearing against the Back of the Instrument, thrusts it farther off when there is occasion. The End of the long Screw *g* comes out thro' the Stage at *m*, where it turns round, but acts not there as a Screw, having no Threads that reach so high.

These Microscopes are plain and simple in their Contrivance. All the Parts are Silver, fashioned by Mr. *Lceurwenhoek's* own Hand, and the Glasses, which are excellent, were all ground and set by himself. He gléwed one or at most two Objects on the Point of the Pin belonging to each Microscope, and carefully preserved them there; so that each Instrument, being devoted to one or two Ob-

jects only, could be applyed to nothing else. This Method induced him to make a Microscope with a Glass adapted to almost every Object, 'till he had got some hundreds of them: as he says himself, in the 2d Vol. of his Works, pag. 290, *Mibi quidem sunt centum centumque Microscopia, &c.* All this Trouble and Expence is now saved, by a Set of Glasses to be shifted with great Ease, as the Subject to be examined may require.

The magnifying Powers of these Glasses come short of some now made, but are fully sufficient for most Purposes. Of the 26 Microscopes I examined, one magnifies the Diameter of an Object 160, one 133, one 114, three 100, three 89, eight 80, two 72, three 66, two 57, one 53, and one 40 times.

Directions for obtaining an exact Representation or Picture of any COIN or MEDAL.

HAVING taken a perfect and sharp Impression of the Coin or Medal in the finest Sealing Wax, cut the Wax away round the Edges of the Impression, with the Point of a Penknife, or a pair of sharp Scissars.

The Rolling-Press Printers have an Ink for printing off Copper Plates, very different from what other Printers employ in printing Books: work some of this with an Hair-Pencil

Pencil into all the Lettering and hollow Places of the Wax Impression, which are the rising or projecting Parts of the Medal. This done, pass your bare Finger, or a cloth strained upon it, gently but nimbly over the Surface, 'till you perceive the Ink perfectly cleared away, unless where the Letters are, and in the sinking Parts; and after this, rubbing your Finger on a Piece of soft Whiting, pass it lightly over the Surface 'till you are sure it is dry and clean.

Have ready, soaked in Water, but the Water squeezed a little out of them, some Pieces of writing Paper somewhat larger than the Medal. Place one of these on the Wax Impression; and on the Back of the Paper lay three or four Pieces of thick Flannel about the Size thereof.

I should premise, that you must have a Couple of flat smooth Iron Plates, about two Inches Square, and of a Thickness not to bend. The Wax Impression must be placed, with its Face upwards, on the Middle of one of these Plates, before you spread the Paper and Flannels on it; and the other Plate must immediately be laid over them. Then, holding them all tight together, put them carefully and evenly into a little Press, made of two Iron Planks about five Inches and a half long, one Inch and half wide, and half an Inch in thickness: having a Couple of male

Fig 3 Screws

Screws that run through them, with a turning female Screw on each to force the Planks together. And these female Screws must have strong well-tempered Shoulders, whereby to work them. A Figure of this Press is shewn *Plate XVII, fig. 9.*

Things being thus adjusted, holding the Press in your Left-Hand, strike with a little Hammer, first on the Shoulders of one Screw, and then on the Shoulders of the other, to bring the Planks together parallel and render the Pressure every-where alike; unless you find it requisite to give more Force to one Side than the other, which these two Screws will put in your own Power.

The Press opens again, by a Stroke or two of the Hammer, the contrary Way, on the Shoulders of the Screws: and then you will find a true and fair Picture neatly printed off; which (if any Deficiencies appear therein) may easily be repaired, when dry, with a Pen and Ink, or, what is better, a Pencil and Indian Ink.

This Method is very easy and ready for taking the Picture of a Medal either in Black or Red; proper Ink of both which Colours may be had of the *Copper-Plate Printers*: but your Wax Impression must be different in Colour to that of the Ink you use, otherwise you cannot see when the Ink is well cleared away; and as the whole Success depends

depends on the Goodness of the Wax Impression or Mould, the following Rules, taught by Experience, are commended to be observed.

1. Let the Wax be fine, or it wants a proper Hardness, and the Impression will not be sharp.
2. Spread it wider than the Medal, and of a Thickness in proportion to the *Relievo* of it.
3. Clap on the Medal when the Wax has a moderate Degree of Heat : for, if it be too hot, the Medal is apt to stick : and, if too cold, no good Impression can be taken. The right Time seems to be, just after the Wax ceases to work up with little Bubbles in it.
4. Make not the Impression on a Table, or any hard Body, without several Folds of Paper, or, what is better, a woollen-Cloth, or some soft Leather underneath ; for soft Things give Way to the Pressure and Form of the Medal, which hard Bodies will not do.
5. Squeeze the Medal down equally hard on every Side, and continue the Pressure till the Wax is near cold : for if the Medal be taken off while the Wax remains hot, the rising Parts being still soft, will sink down, and the Impression be much less sharp.

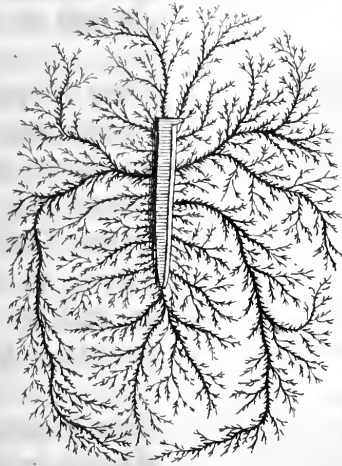
6. White PASTEBOARD, Card-Paper, or some other thick Paper, is best to take Wax Impressions on.

In Places where *Copper-Plate Printer's Ink* cannot be had, Water-Colours may be made use of. Lake and Vermilion mixt make the most proper Red, Indian Ink the best Black. Directions for other Colours may be seen, *Phil. Trans.* N^o 472, p. 82; in an Account of this Invention laid by me before the *Royal Society* Anno 1744, from whence this is partly taken.

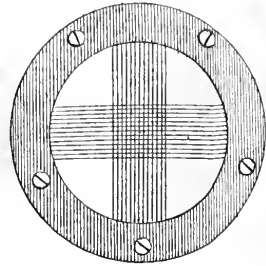
There are indeed many other ingenious Contrivances for taking off Medals, in Sulphur, Plaster of Paris, Paper, &c. But since a Mould must be formed for each of these, either of Clay, Horn, Plaster of Paris, or some other Materials, which requires a great deal of Trouble and Time to form, this Method I believe will be judged abundantly more convenient, especially as some of those ways do really a great deal of Injury to Medals, by impairing the Sharpness of their most delicate and expressive Strokes.

For Wax is always ready, and hurts not the finest Medal: and however brittle it may be thought, the Moulds made thereof resist the Force of downright Pressure, almost as effectually as if they were made of Steel; and might serve to take off a thousand Impressions, were they not apt to crack, and the Marks of those Cracks to render
what

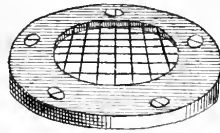
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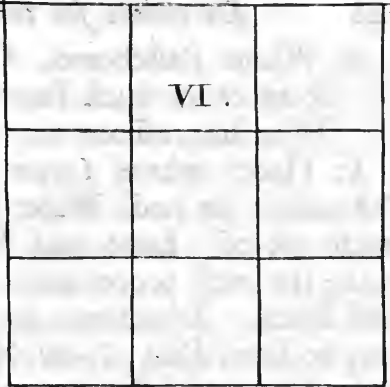
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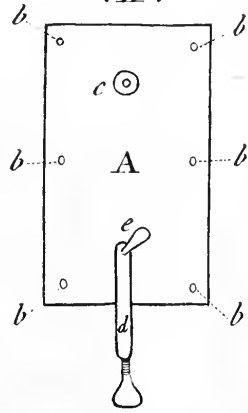
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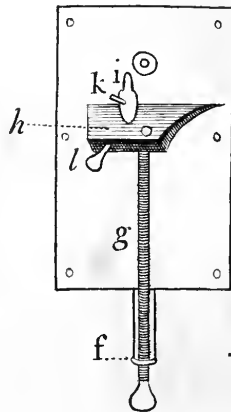
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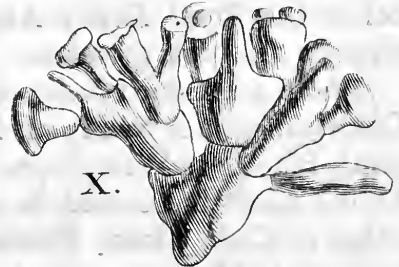
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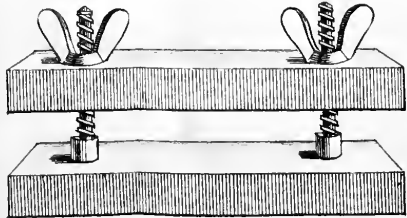
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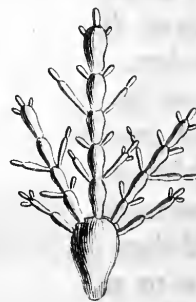
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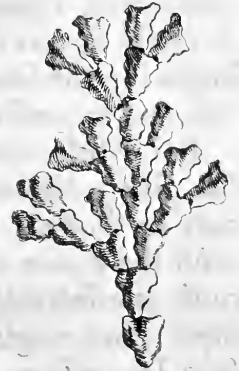
IX.



XI.



XII.



... are taken from their respective ...
... But such should still ...
... or less good ...
... and if the ...
... the same Wax may be ...
... level, France.

... the ...
... the ...
... Wax ...
... Wax ...

... Wax ...
... Wax ...
... Wax ...

... Wax ...
... Wax ...
... Wax ...

... Wax ...
... Wax ...
... Wax ...

what are taken from them afterwards not quite so elegant. But each Mould will usually afford three or four good Impressions, either coloured or plain; and if the Ink be got off clean, the same Wax may be melted and employed several Times.

It is evident, that Impressions taken thus, must be exactly what the Medals are from whence we take them, and that any Person who can procure the Wax Impressions of Medals, may, by a little Pains, be furnished with a noble Collection of the genuine Prints of Medals; which may be placed in Books, in orderly Series, and moved from one Leaf to another at Pleasure; if a little Margin be left about them, and only the Edges be pasted down. I flatter myself therefore, that the Usefulness of this Contrivance will not be slighted, on account of its being so plain and obvious, that every Gentleman will wonder he did not hit on it himself; since Discoveries that are most easy, and consequently may be practised by every body, however simple and void of Invention they may appear, are really in themselves most valuable. I need only instance the Art of Printing, (from which this in some sort is borrowed) the most happy Discovery that perhaps was ever made by Man; yet seemingly so easy, and what the Ancients came so near to in their Seals, that
it

it is extremely surprizing they did not find it out.

In this Manner I have taken off many thousands of Coins and Medals for myself and Friends : and as any Gentleman may divert himself by doing it, I hope this Account of it may prove acceptable.

As the last *Plate* was not finished till the whole Book was nearly printed off, whereby some Figures in it are not described in their proper Places : It may be needful to inform the Reader, that N^o I, II, III, are different *Branchings of Copper*, produced by the several Mixtures mentioned CHAP. LIII. PART I.----That N^o X, XI, are two Species of *Corallina marina*, and N^o XII a Species of *Fucus marinus*, all magnified by the Microscope.

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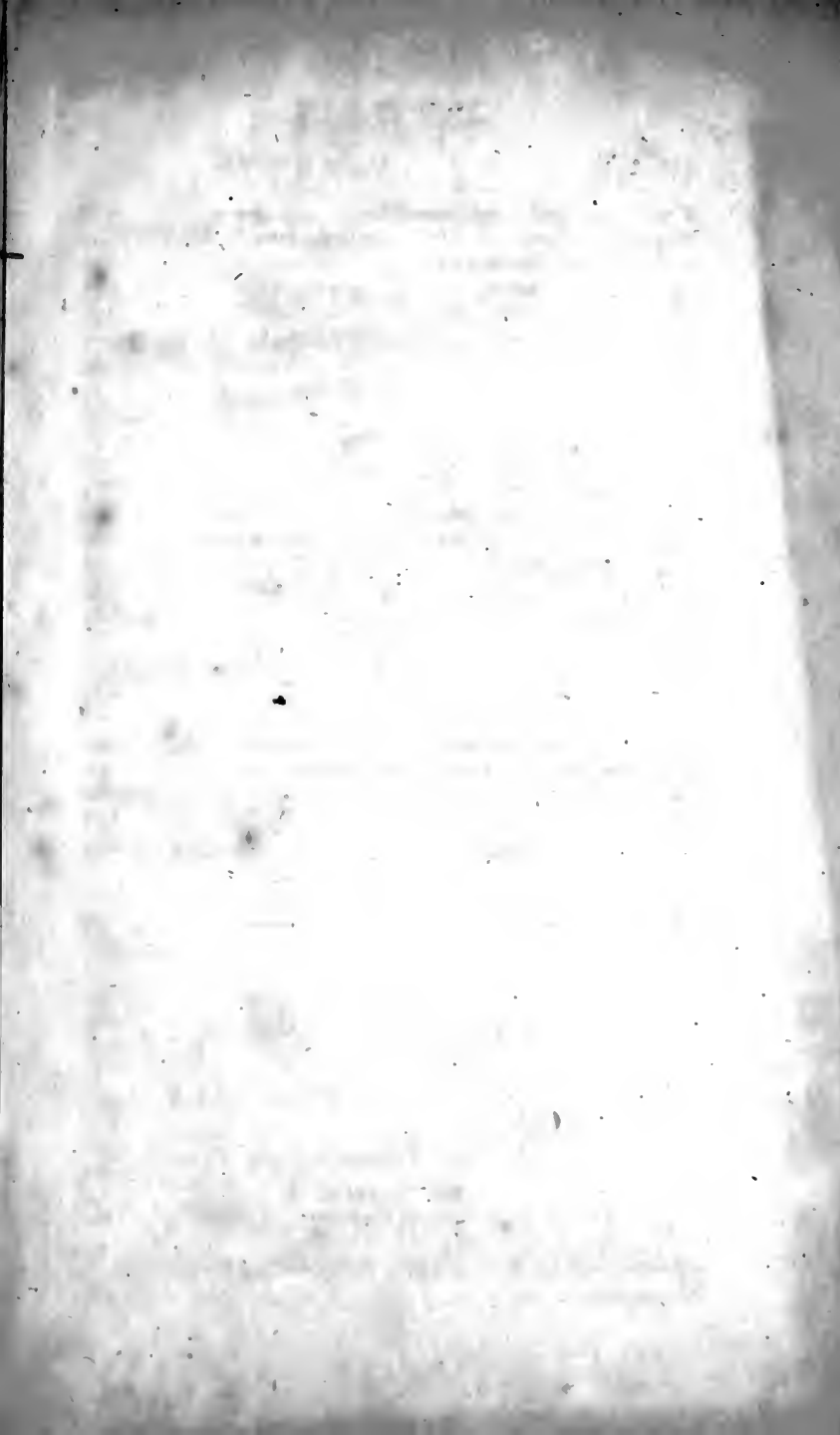
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